THE CITY AS A SYSTEM

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ABSTRACT

THE CITY AS A SYSTEM

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Submitted to the Department of Architecture on June 17, 1968 in partial fulfillment of the requirements for the degree of Master of Architecture.

It is the basic directive of this thesis to establish, correlate, and synthesize the general principles and parameters for studying the city as a system as an abstract model or tool for insight and future development in this critical and vital area. Man has reached a new epoch in his civilization with the advent of new developments technically, socially, economically, and politically - we are on the very threshold of a new era of challange. It lies for those of dedication and vision to implement the blessings of knowledge for the benefit of all mankind. Therein lies the ess of man's endeavors for a balanced society and its architecture. This thesis only claims to be a conceptual, visual, and ordered approach to inspire further ideas that are needed to implement the work of building the cities of the world tomorrow.

This thesis has chosen a city for an urban population of approximately 1,200,000 persons on a flat site within the United States as a point of departure - and as a reality-reference point.

Thesis Supervisor: Eduardo F. Catalano
Title: Professor of Architecture

ACKNOWLEDGEMENT

This is a brief, but grateful acknowledgement to our thesis advisor Professor Eduardo F. Catalano and his assistant, Professor Waclaw Zalewski, for the opportunity, priviledge, and inspiration given to us while here under the Master's Degree program of Integrated Building Systems. Professor Catalano's interest and drive for utilizing the vast potential of creative resources within man's potential deserves commendation - we as his students affirm that approach.

For in the past echoes the words of yet another ambassador of architectural order to reinforce the training and profession we have undertaken:

> "Make no little plans; they have no magic to stir men's blood and probably will not be realized. Make big plans; aim high in hope and work, remembering that a noble, logical diagram once recorded will never die, but long after we are gone will be a living thing, asserting itself with evergrowing insistency. Remember that our sons and grandsons are going to do things that would stagger us. Let your watchword be order and your beacon beauty."[1]

[1] The Urban Pattern by Arthur B. Gallion, pg. 374

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GENERAL STATEMENT

General Statement:

The proper perspective that this endeavor must be placed in lies in the attempt to carry the approach of studying architecture as an Integrated Building System to the next scale - that of study the city as a system. Where the structure and components reflect the various stresses and functions of the city in an interrelated regulatory whole - capable of growth and change in a sequential and controlled process. Where there has been enough vision to anticipate the needs of future generations within the resources, technology, and abilities of the persons undertaking those responsibilities. It is from this departure point, that the city can be studied as a total system, viable and self sufficient as a design entity, that the following thesis is promulgated.

It is well for us to heed the advice of the late Eliel Saarinen, "Something new and constructive must be born to save our culture from distruction. But no lasting results can be had unless one particular problem, fundamental indeed, is properly solved - that people be provided with both satisfactory accommodations and healthful environments in which to live and work. It must be borne in mind that the family and its home are the corner stones of society, and that man's physical and mental development depend largely upon the character of the environment in which he is nurtured as a child, where he spends his manhood, and where he does his work. The more home and environment (city) elevate man-individually and collectively-to candor of living and sincerity of work, the better can society be prepared for a social order that will be lasting.

Because a large percentage of the nation dwells in urban communities, these communities must be formed or reformed into homes and healthy invironments, both physically and spiritually."[2]

[2]The City by Eliel Saarinen, page 1; M.I.T. Press-1966

GENERAL DESIGN PHILOSOPHY

1. Design Philosophy
2. Order
3. System
4. General Principles of Organic Growth
5. Specific Principles of Organic Growth

DESIGN PHILOSOPHY

Introduction:

1. "From inorganic structures to plants and animals, from the movements of animals to their social behavior patterns and to human relations, structure is central. A dramatic focus of structure awareness has been reached through understanding of the molecular structure underlying the generic mechanism of living forms. Inherent in the spiral structure of the complex molecule DNA is the ability to reproduce itself. Thus, a built-in program of growth and development is provided for an infinite variety of unfolding structures of living forms."

   Gyorgy Kepes
   Structure and Art in Science

2. "This is a theory about the process of design; the process of inventing physical things which display a new organization and form in response to function... These physical relationships interact, and a problem can be solved only when these interactions can be patterned into small and relatively independent subsystems...The form that the building will take derives from the these sub-systems of physical relationships...Once the physical relationships of a problem are stated, there will be a best form for that problem as stated...Even though a better statement of the problem may always yield a still better form. The ultimate object of design is an environment...which has no relationships in it that are not working to some specific purpose."

   Christopher Alexander
   The Theory and Invention of Form

Design Philosophy:

The purpose of this chapter is to provide some of the major guideposts, or signs which proved to be consistent criteria for the establishment of our program, problem difinition, basic and specific research, synthesis, and final design methodology-In summation, a Design Philosophy.

Preface

This aspect is the most critical and is the foundation of all and any endeavor in architectural design and planning. Here the author's have attempted to premise the bulk of the decisions on principles that transcend time, irregardless of current styles and fashions, and attempt to correlate to the laws or governing principles that bring harmony and beauty to the world we live in. This is an elementary premise, but one of deeper elaboration and reinforcement. The main or chief motivation of attempting to establish and recapture the true values, laws, and principles of architecture is to bring once again an established art and profession into the realm of providing a lasting and satisfying environment. Either this premise will endure in the coming years, or we can have the alternative of being the Facade Formulators or the Survival Engineers of Tomorrow's World-both of the latter alternatives reflect an attitude of hopelessness and frantic anxiety which will inevitably be fruitless. We have seen enough of the fruits of the blind leading the blind, and both leader and follower fall into the ditch.

This aspect of chaos and confusion is the "roll call" of the day for most cities in today's major urban regions, irregardless of the locality with respect to race or continent. Wither it's the urban sprawl in Los Angeles,

California, or the refugee settlement programs of the new colonies adjacent to Hong Kong, or the insane constriction of New York City, Babylon of the American Empire, we have to come to grips with some of the lasting values that provide for equilibrium and harmony, and upon reaching a saving level of understanding, apply that knowledge to being both abundance and life-It is as simple a congnitive fact to recognize the law of gravity and acceleration, than to deny its validity by jumping off a ten-story building, only to regret the result in organizing anticipation of the climax. This reflects the current crisis of our cities today-premised on criteria anachranous to current developments, and a flexibility rate of such resistance that the present out look is mortifying. Therefore, in the attempt to establish and recapture the true values of architecture, regardless of time and scale, it was necessary for us to establish a hypothetical model of the critical variables of any city, to determine optimum density, volume, size, and correlated functions within the primary structure over sequential growth period. Because the general and specific research required was of such magnitude in the formation of such a program, our major focus was to provide a sound, valid, and directional platform for which further studies can be implemented in the coming classes in this vital and most promising study area-
The City As a System.

Order:

This represents one of the fundamental principles governing all bodies of life and growth that man has been able to discern over recorded history. The over all pattern of intricately interbalanced congruous systems that provide for a harmonious environment has been a valid premise to provide a design standard for many disciplines, including architecture and city planning.

Why has the field of architecture and design inquired, and in many cases, so carefully into this rationality or methodology of applying the principles of nature into practicality? Because, man, through his trial and error procedures experiences the reciprocal nature of the cause-effects and his tremendous natural drive and inquisitiveness for greater control and understanding of himself and his society, has acknowledged that by the environment around him, he hopes to unlock the key principles that will establish him to a new level--a creator and controller of his physical environment. Such a presumptuous and vain attempt, which is easily discernible in the realm of physics, medicine, and biology, completely dismisses the concept of a Supreme Being, a God who established and provided this in the first place.

This is a crucial issue in the area of design methodology--the acknowledgement or dismissal of an "a priori" condition. A condition that unifies or substantiates if there is a design and order in our physical environment, there must be a Form Giver; and it there remains the law of "biogenic", that life can only develop from life", that there must be a Life Giver, and finally, that if there are physical laws of gravity, light, and motion, it remains irrefutable that there is a Law Giver. It remains within the context of this thesis to provide only "a posteriori" evidence that the above conclusions are inevitable from the Philosophy provided for a general context of the thesis.

The development of this theme quickly requires elaboration and definition of system - one which provides a clear concept of the City as a System.

System:

The purpose of establishing a system definition of our thesis is to provide a useful tool for the description of the various components established as important first criteria, and the interactions of the parts with one another, over a given period of time - providing for the aspect of the system as growth generating phenomena - where from a given set of components, and a governing principle of growth, we may provide a multitude of various alternatives within a single framework. An immediate analogy is the system of musical notation, consistent in any framework or style, yet a infinite number of various alternatives are possible.

Therefore a system represents a governing procedure or relationship - a nonphysical representation that may be developed and altered, and also a physical manifestation of that conceptual relationship which provides a reinforcing reference point to reality.

For example, a building system may be viewed as an integrated development of the following parts and components:

1. Structural System
2. Circulation System
3. Spatial System
4. Service System
5. Mechanical System
6. Lighting and Electrical System
7. Acoustic System

This is one specific context at the next level, we are trying to establish the limits and basic components of the city system. With all its limitations and shortcomings, it is providing an analytical model or tool for studying the basic criteria which defines the various overall fundamental variables which remain consistent over time. They are the following:

1. City Area
2. City Density
3. City Function
4. City Volume
5. City Circulation
6. City Structure
7. City Growth

The above variables were selected because they provide a common reference point to make alternative variations within any given system. This provides a consistent basis for evaluation - an inherent aspect of any design philosophy.

All of the above permanent variables again are subjected to the following performance characteristic, at the abstract level. They are the following:

1. Diversity: the multiplicity of facilities and activities, and their combination in various degrees.
2. Adaptablity: the ability of an urban setting to adapt to various changes without seriously affecting the environment adversely.
3. Satisficing: Highest possible standards of adequacy maximize level of performance of various facilities - residential, schools, shopping, etc.
4. Accessibility: The maximum ability of the individual to communicate or move through the city providing, in turn, maximum interaction.
5. Manipulability: the ability of the individual or limited group to change and modify the environment. A "do-it-yourself" world which invites exploration, stimulates education and encourages creativity.

6. Flexibility: The ability of the environment to react favorably to stress, to withstand breakdown, or speedily recover from disasters.
7. Equilibrium: The balancing of many objectives in providing a "healthy" city. It is the "give" and "take" of goals in order to reach a rational compromise in city design.[3]

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3 The Design of a New Town by Lawrence S. Gordon, M.I.T. Thesis, 1967

The General Principles of Organic Growth:

In basic architectural philosophy, the principles of organic growth have provided inspiration and influence upon many of the current architectural and city planning disciplines, both here and abroad. In America, its early developers were the late architects Frank Lloyd Wright and Eliel Saarinen. Currently, its most intensive development is under Professor Eduardo F. Catalano, our thesis advisor here at M.I.T, and the metabolist group of Japan - Tangi, Kurowaka, and Kikutaki.

With the advent of technology as an effective tool for material productivity and efficiency, the architectural profession has gone into other disciplines for correlation and explanations of ever more complex and indeterminate structures. The field of biology, where intensive research elaborated on cellular growth and form, has provided the architectural philosopher or student with some direct insight and general understanding of man's environment to the scale level of the amoeba, plant cells, molecular structure, crystallography, etc.

This continuity of order from one scale level to another (micro to macro) has given man much insight into the way physical structures can be designed into a tool regulatory system, integrated into its scale environment and self sufficient within its own limits - a substantial part of the systems theory in architecture and planning.

This permitted the architect to give a classification system to his variety of endeavors, from suspension, to rigid frames, and bearing wall systems; just as much as the initiators of biology gave the technical names to over all families of plant and animal life, and from reptiles, fowl, mammals, insects, and fishes, - and within each family group, various species of an infinite variety developed. Each type represented a particular productivity within that system. Yet they still remained within the confines of the family system which is originated from.

This concept is forthrightly expressed by Eliel Saarinen in the book, The City: "It is amazing to learn that the whole universe, from the most microscopic to the utmost microscopic, is constituted along this dual thought of individuals as such and the correlation of these individuals into the whole (family). Furthermore, one learns that vitality in all life manifestation depends, first, on the quality of the individual and second, on the quality of the correlation."

It is from this basic understanding that we have been able to appropriate the concept of the family, or Genesis in biological terms, to the concept of systems. Both are fundamental expressions of the same idea, but used in two separated fields of thought. Both have a hierarchical structure, or order of the units (individuals) within the limits of the system (family); and both emphasize the enity and the interdependence of the units to each other. So here is a continuous application of a single principle which exists irregardless of specie, scale level, or time limitation. That principle is that of the Family or System - whichever is more amenable to your vocabulary. And the most dominant living form existing on earth today reflects the essense of that interrelated, harmonious, and ordered structure - that unit is man (individual) and its basic structure is the family (system). It has its own unique requirement of basic components, its interdepending of units, and its growth process.

The Specific Principles of Organic Growth:

In this study of The City As A System, we have ventured into specific examples drawn from nature to substantiate our design philosophy - herein lies the roots of our inspiration and attitude towards developing a complex interacting city system.

The first specific example is the "Transverse Section of a Stem of Kadsura: taken by Professor I. W. Bailey of Harvard University - see plate no.1 . This photomicrograph appropriately provides a visual expectation of several key relationships to support our design approach for a city of 1,200,000 persons on a flat site. The major principles evident within the transverse section are the following:

1. Differentiated Planar Distribution:
   a. The section shows an even planar distribution of major forms along two principle symmetrical axes. The Y axis is of single polarity versus the X axis of the bi-polarity - an aspect of differentiation regarding equal distribution of material. Note the equivalent number of force lines - or symbolically 2X=Y.
   b. Also of importance is the differentiation of planar density. The photo shows a central core composed of an integrated composition of various cellular units - juxtraposed to each other, yet functioning as an integrated part. Beyond the central core, we find subcores (6) of smaller unit cells in gradual transition to the force lines, this may signify a node of juncture point.
   c. The outer fringe area is of consistent density and distribution, homogenuous, yet

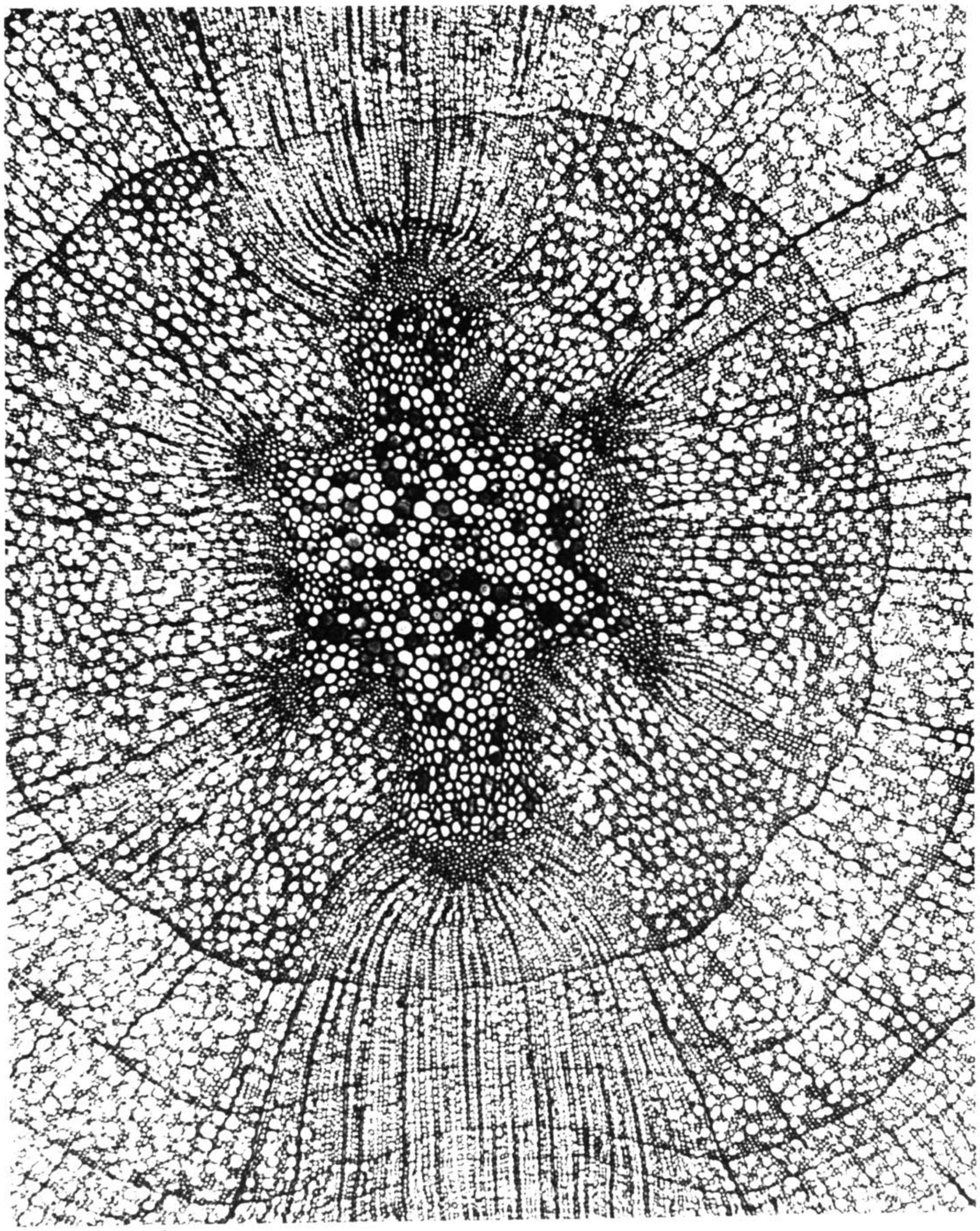


Plate No. 1 <u>TRANSVERSE SECTION OF A KADSURA STEM</u>
Differentiated Planar System with a central core and a core fringe.

Photomicrograph: Prof. I. W. Bailey, Harvard University - The New Landscape by Gyorgy Kepes Pg. 129

ordered significantly in terms of growth. Note the annular rings surrounding the cores! They are not equally incremented. The succeding stages follow a definite ratio of area distributed to the distance that area is located to the central core; each growth stage is directly related to the previous one, and together, they provide a spatial equilibrium to the core. It closely approximates that of the golden section - a ratio of 0.618:1.0.

2. Structural Continuity:

a. The photograph clearly shows structural continuity of the lines of force up to the sub-core nodes, but also between subnodes through the central core, the cellular structure reflects continuity. Therefore, a stable planar condition exists. If the lines of force did not exist in structural continuity, the system would not be planar and symmetrical, but the very reverse.

The annular rings are complete and unbroken - significantly equivalent to steel tension rings containing the forces imposed upon it - it contains the outward thrust very dramatically.

b. The next specific example is the same specimen, but much larger scale development of the cellular units themselves. Here in Plate No. (2), we can see not only structural continuity, but a hierarchical level of structural force lines. From primary to

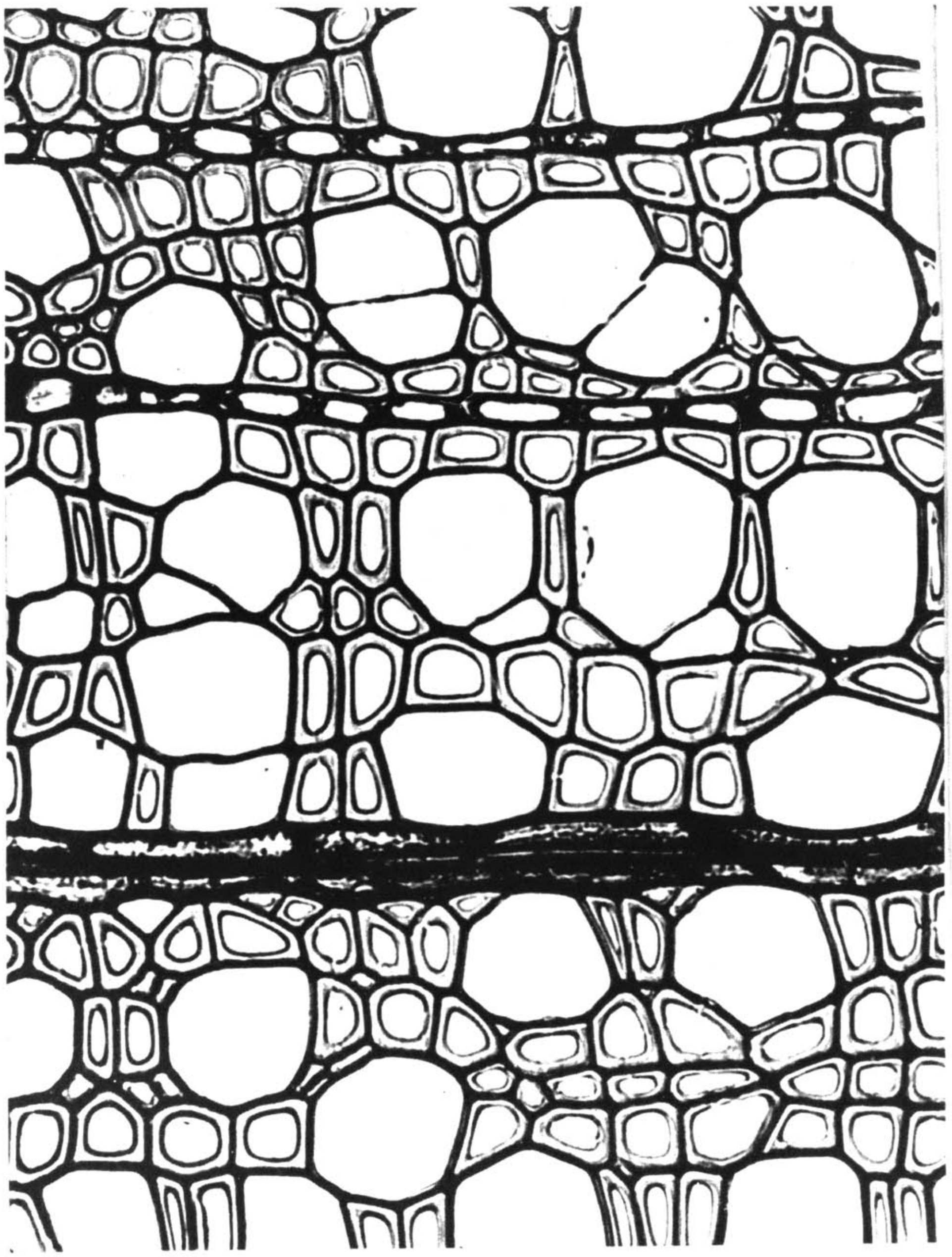


Plate No. 2 TRANSVERSE SECTION OF WOOD
Organic Circulation System

Photomicropgraph: Prof. I.W. Bailey
Harvard University - The New
Landscape by Gyorgy Kepes Pg. 126

secondary to tertiary lines between the cells. It is well to note that the number and spacing of each level of circulation is ordered - and that the width and internal area of each circulation line is consistent. Therefore the principle, once established, is adhered to throughout the whole system.

3. Cellular Stability:

Finally, close analysis of Plate No. 2 - shows that the cellular arrangement provides for support units for the survival of the major activity units - approximately 7 units per cell. Each cell is separated from other cells by these support units - a given stable domain area of each cell. Each cell is healthy and self-sufficient. Note this, all cells exhibited a maximum limit - if this were exceeded, an unstable condition would exist. Similar to most cities where existing land areas are overcrowded beyond any reasonable limit. A premium example is the city of New York, where many city blocks, due to financial considerations have huge density loads imposed upon them. Also due to excessive stresses, many cells may degenerate and decay. If the total system is not functioning properly to regenerate the disintegrating cells, "microscopic slum growth" is initiated. (4) Mr. Saarinen's insight is brief - but explicit:

"Just as any living organism can be healthy only when that organism is a product of nature's art in accordance with the basic principles of nature's architecture, exactly for the same reason town or city can be healthy - physically, spiritually, and culterally - only when it is developed into a product of man's art in accordance with the basic principles of man's architecture."

4. The Basic Growth Processes:

The basic growth processes fall into three major categories. "These are growth, morphogenetic movements, and differentiation. These processes characterize the progressive change in the life histories of organisms."[5] In refering to the schematic diagram on Plate No. 3, it is evident that the three constructive processes sometimes work together, and at other times independently to a certain degree. The same approach to viewing growth characteristics of building systems is appropriate - these principles transcend both time and disciplines.

[4] Ibid p.18

[5] Morphogenesis by J.T. Bonner, Pg. 271 Atheneum - 1952

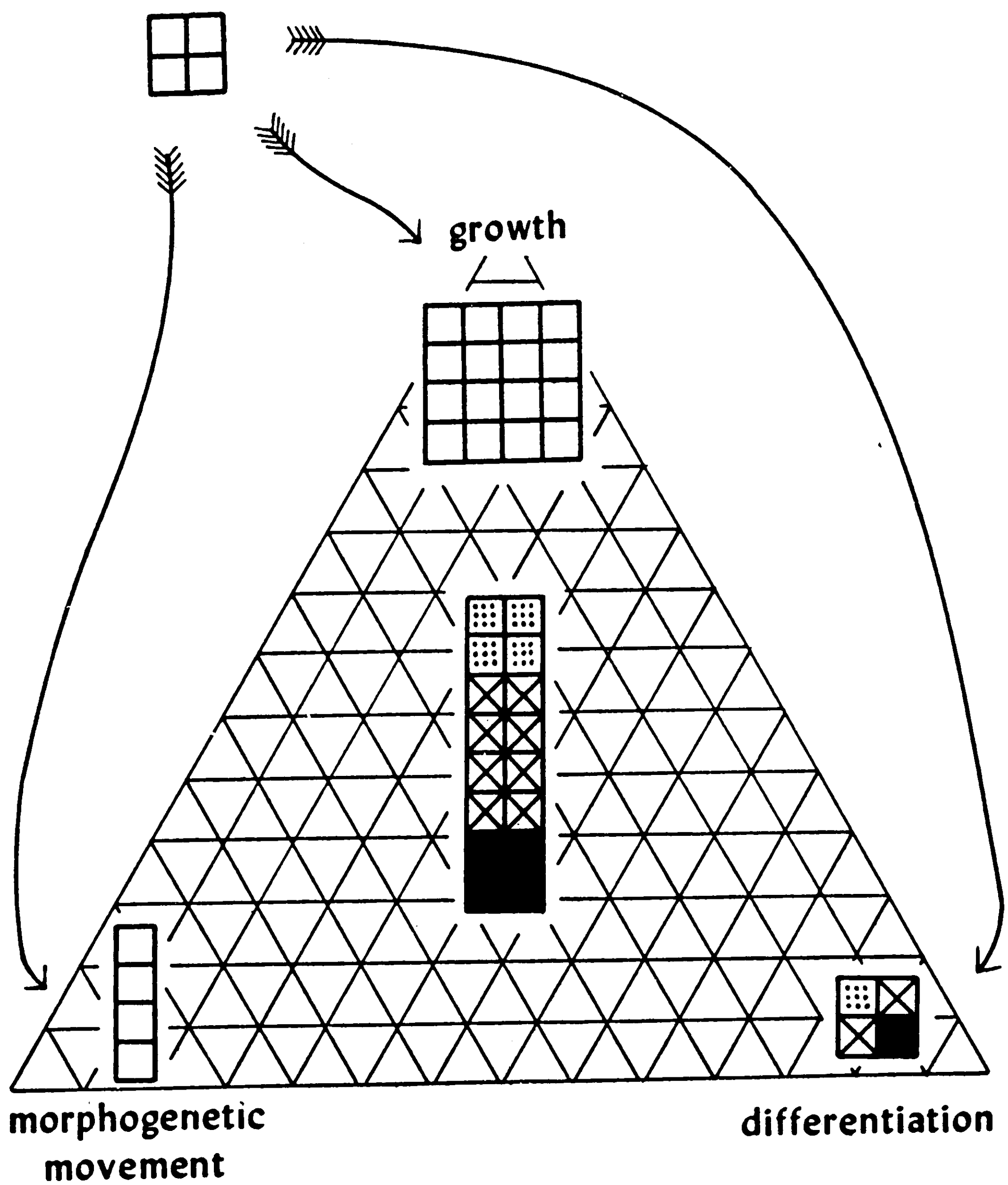


Plate No. 3 THE THREE MAJOR CONSTRUCTIVE PROCESSES

By: John Tyler Bonner
Morphogenesis - An Essay on Development
Atheneum - New York - 1963
Pg. 272

STRUCTURE

1. The Structure of Measurement
2. The Structure of Proportion
3. The Structure of Music
4. The Structural Scale of the City
5. The Hierarchy of Structure

STRUCTURE

The fundamental structures inherent in all physical systems remain abstract ones. The structures are one of relationships, and as previously discussed in the area of organic growth, they have within them, the concept of the unit or cell (individual) and the idea of the hierarchical system (family). This duality remains imprinted upon any coherent and functioning organism, whether it is a viable governmental agency, a complex architectural systems computer program, or just a family unit. In order to give more clarity to this position, the following major non-physical structures have been developed:

1. The structure of measurement.
2. The structure of proportion
3. The structure of music

For it is an inherent part of the authors position that the abstract relationships - quantitative and qualitative are the ones that provide for understanding of physical systems.

1. The Structure of Measurement:

This study proved to be more than just an erudition of details, but a search for understanding - and for the common denominators that spanned the various increments we use for measuring time. The building blocks (cells) of change, or transformation, of development from one stage to another. It is from this idea of flexible system of interdependent units, that a system of interchangeable spans for a building system could be developed. Consider the following structures of common measurement systems subscribed to for ages - based on careful developments which reflect man's astuteness in representing the truth; especially in matters as constant as the movement of the sun and moon around the earth, and the seasons of the year. The system they captured was as durable as that in which they placed it - and those relationships have transcended all of the ages which man has endured - The Structure of Measurement.

1-A. Structure of Time:

The common denomoninator of the following units of time is 12:

No:	Description:	Units:
a.	Months in a year	12
b.	Days in a year	360
c.	Days in a month	30 N.I.A.
d.	Hours in a day	24
e.	Minutes in an hour	60
f.	Seconds in a minute	60

Note: N.I.A. indicates the number is not immediately applicable.

1-B. Structure of Angular Measurement:

The common denominator of the following units of measurement is 30:

No:	Description:	Units:
a.	Degrees in a circle	360
b.	One quadrant	90
c.	Degrees in a sextant	60
d.	Minutes in a degree	60
e.	Seconds in a minute	60

1-C. Structure of Weight Measurement:

The common denominator of the following units of measurement is 12:

No:	Description:	Units:
a.	No. of ounces in a pound (apothecaries weight)	12
b.	No. of ounces in a pound (Troy Weight)	12

No:	Description:	Unit:
c.	No. grains in a penny - weight (Troy weight)	24

1-D. Structure of Linear Measurement:

The common denominator of the following units of measurement is 12:

No:	Description:	Unit:
a.	Inches to a foot	12
b.	Inches in a yard	36
c.	Yards in a mile	1,760
d.	Feet in a mile	5,280
e.	Miles in a light-year	$5{,}880 \times 10^9$
f.	One dozen	12
g.	One gross	24

1-E. Structure of Planar and Volumetric Measurement:

The common denominator of the following units of measurement is 12:

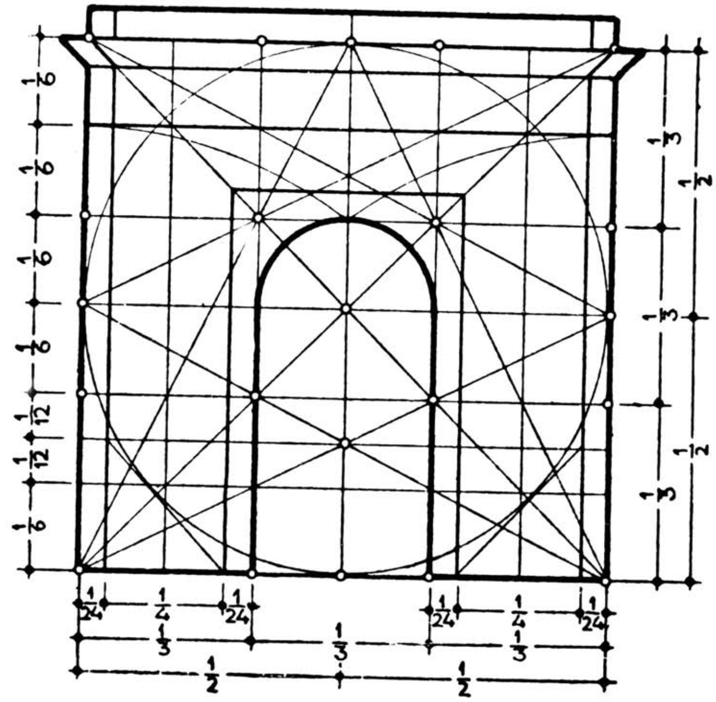
No:	Description	Unit:
a.	Sq. Ft. in an acre	43,560
b.	Sq. In. in a Sq. Ft.	144
c.	Cubic inches in a cubic Ft.	1,728

The value of the above overview on basic measurement structures is that there is a common theme that unifies them together. The first is that any given measurement system provides for a flexible generation of an infinite variety of alternatives within its system; secondly, the major aspect of that theme is the overall significance of the unit 12 as a common denominator - it is a numerical standard that girds or supports almost every measurement structure we know of. It represents the concept of completeness, and it proved to be a valuable tool in establishing a numerical structure for a coordinated system of planning spaces and architectural elements. We know it today as the principle of modular co-ordination a fundamental aspect of today's building industry.

2. The Structure of Proportion:

From the previous section, we have gained a preliminary insight into the concept of family systems of measurement. The next major step in the development of structure is into the structure of proportion. Here lies one of the fundamental constraints that has tantalized and inspired many architects, both past and present. For from it, much heritage has been developed. The Greeks implemented it in their temple architecture, giving exact relationships of the various parts to the whole - the Parthenon in Athens being the epitome of such discernment. The Arch de Triomphe in Paris by Blondel shows a literal interpretation of integrated proportional variations impressed upon the facade - see plate No. 4 . Even the late Le Corbusier, whose impact on current renovations in architecture is clearly evident, was subjugated, and liberated by the Modular System. Yet it provided for harmony and order to his work; and it remains to us as a vivid lesson that discipline coupled with character provides for a true architectural philosophy. It takes substance to bring forth substance: "The act of creation is a patient search," said Le Corburier.

The structure or proportion falls into two general classifications - both interdependent upon each other. The first is the (1) Proportional Number System; and the second is the (2) Proportional Modular Systems:



9.19 Diagramma di proporzioni del Blondel
9.20 Interpretazione di Le Corbusier della modulazione di Blondel

Plate No. 4 ARCH DE' TRIOMPHE
Proportion Blondel

By: Milan Zlokovic
La Coordinazione Modulare - Pg. 151

Proportional Number Systems:

2-A. The Platonic Lamda:

This represents the one of the simplest developments in proportional number system. It consisted of two series. The first is the doubling series (ratio of 1:2) and the second is the tripling series (ratio of 1:3).

a. The Doubling series provided for linear growth in an ordered sequence:
   1, 2, 4, 8, 16, 32 .....etc.

b. The Tripling series provided for linear growth in the following sequence:
   1, 3, 9, 27, 81.....etc.

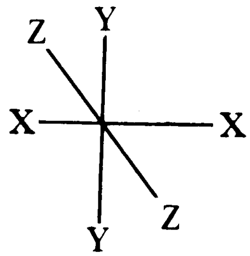
These two series were used to complement each other either in the Greeks music or their architecture.

2-B. The Composite Series:

The composite series is the next development - it implemented the single series structure to that of the Landa series to provide us with a three dimensional grid of ordered numbers. Each of the principle axes of orthogonal geometry was given a series ratio. The Y or vertical axis was given the single (adding) series with a ratio of 1:1. The X or horizontal axis was given the doubling series with a ratio of 1:2. And finally, the Z or perpendicular axis was given the tripling series with a ratio of 1:3. See Plate No. 5 for a visual translation of that concept.

2-C. The Fibonocci Series:

This is one of the most venerated and illustratious series ever proclaimed in mathematics, and consequently in architecture. It represents the ratio of 1:1.618 and its mathematical series was discovered by Filius Bonacci in the sixteenth century - Fibonacci being a contraction of his two names.



A	B	C	D	E
9	18	36	72	144
18	36	72	144	288
27	54	108	216	432
45	90	180	360	720
72	144	288	576	1152

A	B	C	D	E
3	6	12	24	48
6	12	24	48	96
9	18	36	72	144
15	30	60	120	240
24	48	96	192	288

A	B	C	D	E
1	2	4	8	16
2	4	8	16	32
3	6	12	24	48
5	10	20	40	80
8	16	32	64	128

Plate No. 5 THE COMPOSITE SERIES

"To double on the X axis, add along the Y axis, and triple along the Z axis".

By: Ezra D. Ehrenkrantz - Modular Materials and Design Flexibility - Module, Proportion, Symmetry, Rhythm by Gyorgy Kepes - George Braziller, New York - 1966 Pg.121

"In this series the two previous terms are added to a third term so that 1 + 2 = 3, 2 + 3 = 5, 3 + 5 = 8, 5 + 8 = 13, and 8 + 13 = 21. The ratio between two consecutive numbers is 1:1.618."

2-D. Pascal's Triangle:

This system is the one of the most complex matrices yet developed by man. It's variations and depth include all of the previous series discussed, and other spectacular relationships known within the field of mathematics. It represents an array which is infinite and bilaterally symmetric. The diagonal and horizontal rows as shown in Plate No. 6 represents unique series (ratios) which have their own proclivities. For instance, the horizontal rows represent the coefficients of the standard (exmpandable) quadratic equation. The lesson to be learned is the translation of this matrix into the concept of a unit (cell) and its function to the total system (family).[6]

2-E. 4" Modular Composite Series"

This example is a direct translation of the composite series using just 6 elements or unit sizes on an incremental variation of 4". The major lesson to be learned here is that within a given system of only 6 inter-related elements, a wide variation of alternatives is possible. This is a fine example of the concept of flexibility within a system. The chart shown on Plate No. 7 shows 16 major variations within the scale limit of 5'-0" to 10'-0" and the total number of permutations is 87. This also shows why given principle, once generated

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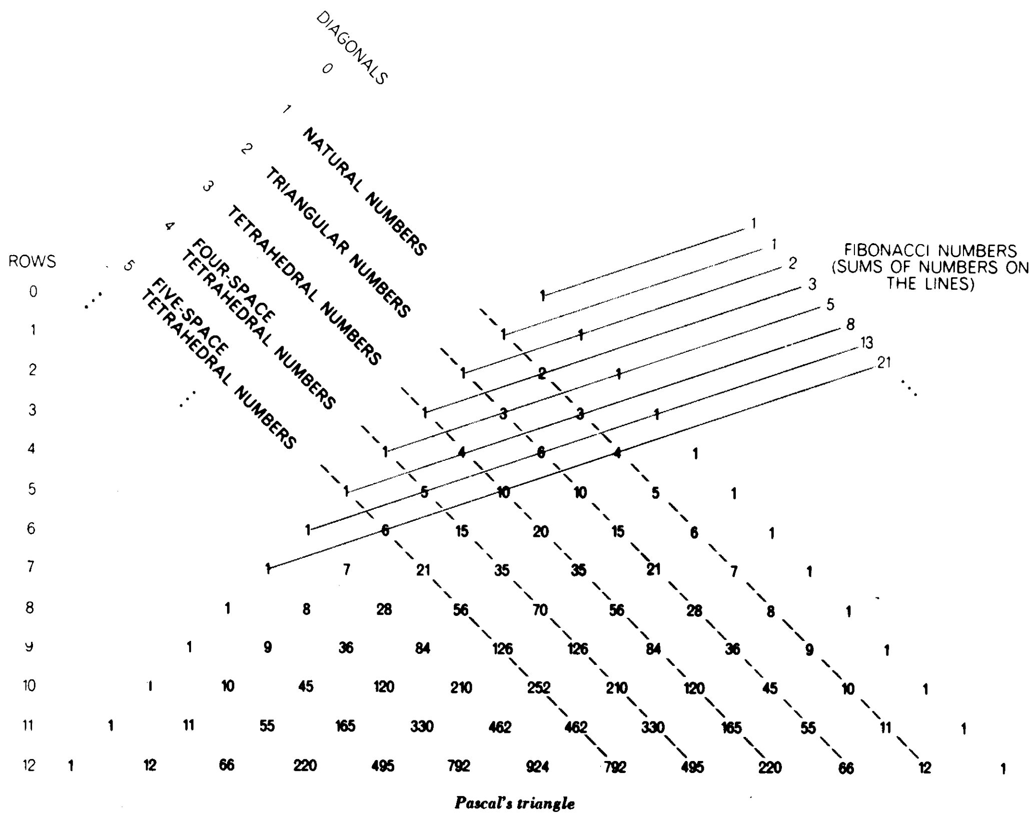
[6]The Multiple Charms of Pascal's Triangle by Martin Gardner, Scientific American p. 129.



Pascal's triangle

Plate No. 6 PASCAL'S TRIANGLE

By: Martin Gardner - The Multiple Charms of Pascal's Triangle - Scientific American December, 1966 Pg. 129

20	24	36
5'0"	20 + 20 + 20	
	24 + 36	
	20 + 40	
	60	
5'8"	24 + 20 + 24	
	48 + 20	
6'4"	36 + 20 + 20	
	36 + 40	
7'0"	24 + 20 + 20 + 20	
	48 + 36	
	24 + 36 + 24	
	60 + 24	
	20 + 40 + 24	
7'8"	24 + 20 + 24 + 24	
	24 + 20 + 48	
	36 + 36 + 20	
8'4"	20 + 20 + 20 + 20	+ 20
	36 + 24 + 20 + 20	
	20 + 20 + 20 + 40	
	40 + 20 + 40	
	36 + 24 + 40	
	60 + 20 + 20	
	60 + 40	
9'0"	24 + 20 + 20 + 20	+ 24
	24 + 24 + 24 + 36	
	48 + 20 + 20 + 20	
	48 + 24 + 36	
	60 + 48	
	36 + 36 + 36	
	60 + 24 + 24	
9'8"	36 + 20 + 20 + 20	+ 20
	36 + 20 + 24 + 36	
	20 + 40 + 36 + 20	
	36 + 40 + 40	
	60 + 20 + 36	
	48 + 48 + 20	
	24 + 24 + 48 + 20	
	24 + 24 + 24 + 24	+ 20

40	48	60
5'4"	24 + 40	
	24 + 20 + 20	
6'0"	24 + 24 + 24	
	48 + 24	
	36 + 36	
6'8"	20 + 20 + 20 + 20	
	20 + 20 + 40	
	40 + 40	
	36 + 24 + 20	
	60 + 20	
7'4"	24 + 20 + 24 + 20	
	24 + 40 + 24	
	20 + 48 + 20	
	48 + 40	
8'0"	24 + 24 + 24 + 24	
	48 + 24 + 24	
	48 + 48	
	36 + 24 + 36	
	20 + 20 + 36 + 20	
	36 + 20	
	20 + 36 + 40	
	36 + 60	
8'8"	24 + 20 + 20 + 20	+ 20
	24 + 20 + 24 + 36	
	24 + 20 + 40 + 20	
	24 + 40 + 40	
	60 + 24 + 20	
	48 + 36 + 20	
9'4"	24 + 20 + 24 + 20	+ 24
	48 + 20 + 20 + 24	
	40 + 24 + 24 + 24	
	40 + 48 + 24	
	40 + 36 + 36	
	20 + 20 + 36 + 36	
10'0"	20 + 20 + 20 + 20	+ 20 + 20
	20 + 20 + 20 + 20	+ 40
	20 + 20 + 40 + 40	
	24 + 36 + 20 + 20	+ 20
	24 + 24 + 24 + 24	+ 24
	24 + 36 + 24 + 36	
	24 + 36 + 20 + 40	
	40 + 40 + 40	
	60 + 60	
	60 + 20 + 20 + 20	
	60 + 36 + 24	
	60 + 20 + 40	
	48 + 48 + 24	
	48 + 36 + 36	
	48 + 24 + 24 + 24	

Plate No. 7 <u>4" MODULAR COMPOSITE SERIES</u>

4" inch Flexibility using Six Product Sizes.

By: Ezra D. Ehrenkrantz - <u>Modular Materials and Design Flexibility</u> - Module, Proportion, Symmetry, Rhythm by Gyorgy Kepes - George Braziller, New York - 1966 Pg. 125

properly, provides for an infinite number of possibilities within any given system structure.

2-F. Le Modulor:

This numerical series, Le Modulor, was expounded as the central and indivisible theme of the late Le Corbusier in his work as an architect, city planner, and artist. Undoubtedly, his search to relate the measurement of man, see Plate No. 8 , symbolized by Rusconi in 1590, and the continuity of two equivalent ratios endurably stamped in mathematics. They are the Fibonacci series and the Golden Section (sectio aurea) which are described by the ratio of 1:1.618. Plate No. 9 explains the modulor system of dimensioning in both inches and meters. They represent two variations structured on synthesizing several related principles in a total ordered proportional numbering system.

2-G. The 60 CM-6M Tripart Proportional System:

This proportional series of modular orthoganal geometry represents a unique concept - a family unit of a given increment, yet three distinct species, or subsets within that unit. In this case the particular unit is 60 centimeters or meters; it can easily be translated into other proportional and measurement systems. The examples shown on Plate No. 10 , clearly show its structure, growth pattern, and overall principle of coordination. Again, the number 12 is a common denominator of this system. This diagram is invaluable in providing future studies into the concept of interrelated modular spans of construction.

3. The Structure of Music:

There have been many comparisons of music to architecture; including the favorite adage that expressive architecture is frozen music. In the search of various quantitative and qualitative structures devised by man

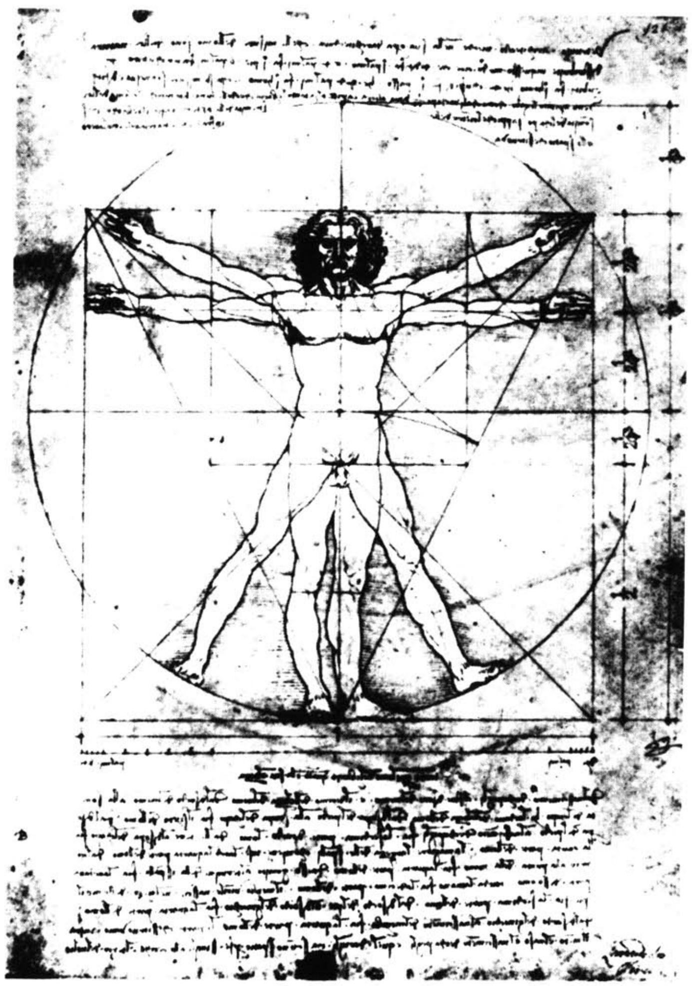


Plate No. 8 MAN & PROPORTION

By: Rusconi 1590

By: Milan Zlokovic
Industrializzazione Dell'edilizia
Dedalo Libri, Bari Italy - 1965
Pg. 143

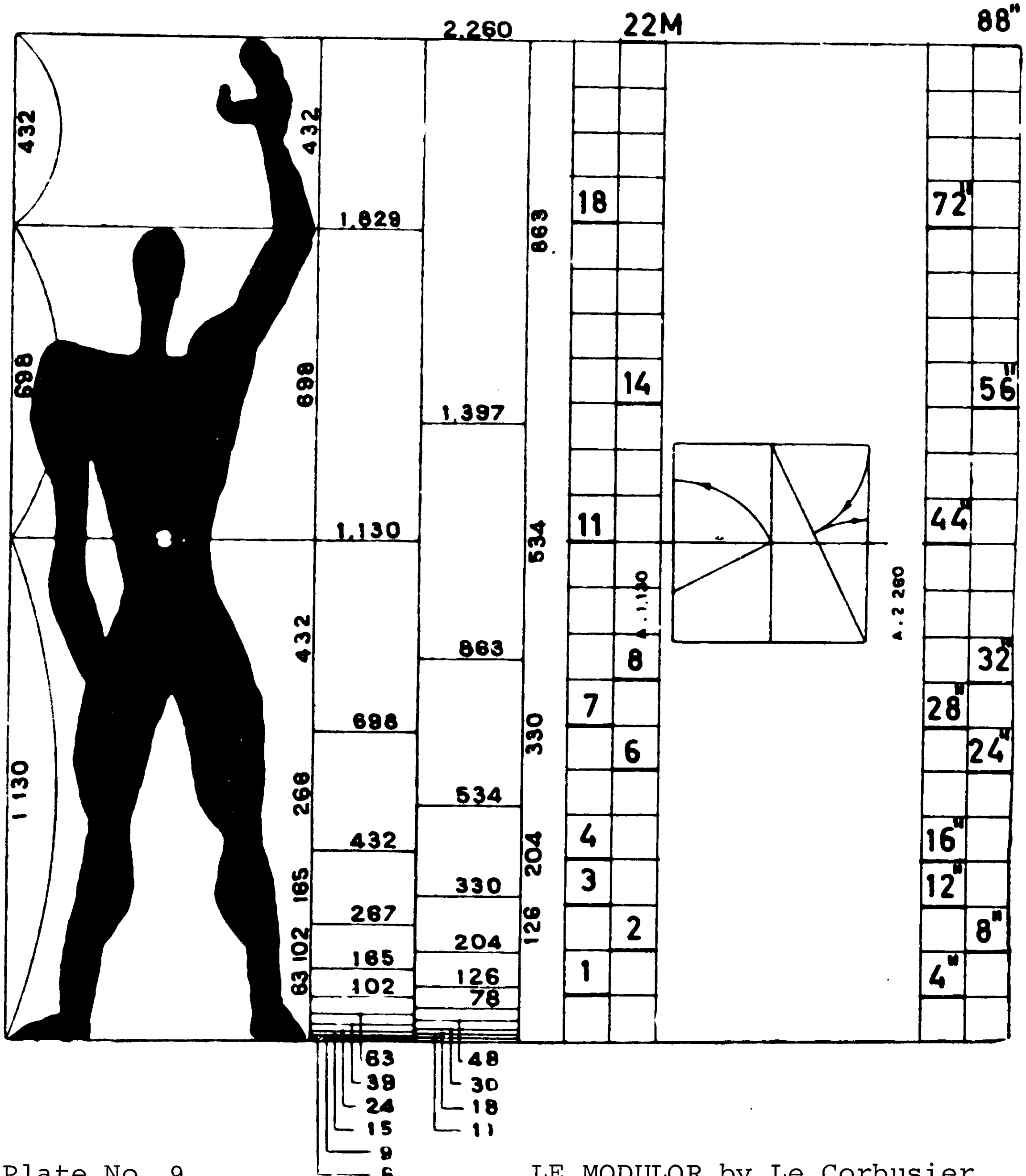


Plate No. 9

LE MODULOR by Le Corbusier

By: Milan Zlokovic
La Coordinazione Modulare
Industrializzazione Dell'
edilizia - Dedalo Libri,
Bari Italy - 1965 Pg. 143

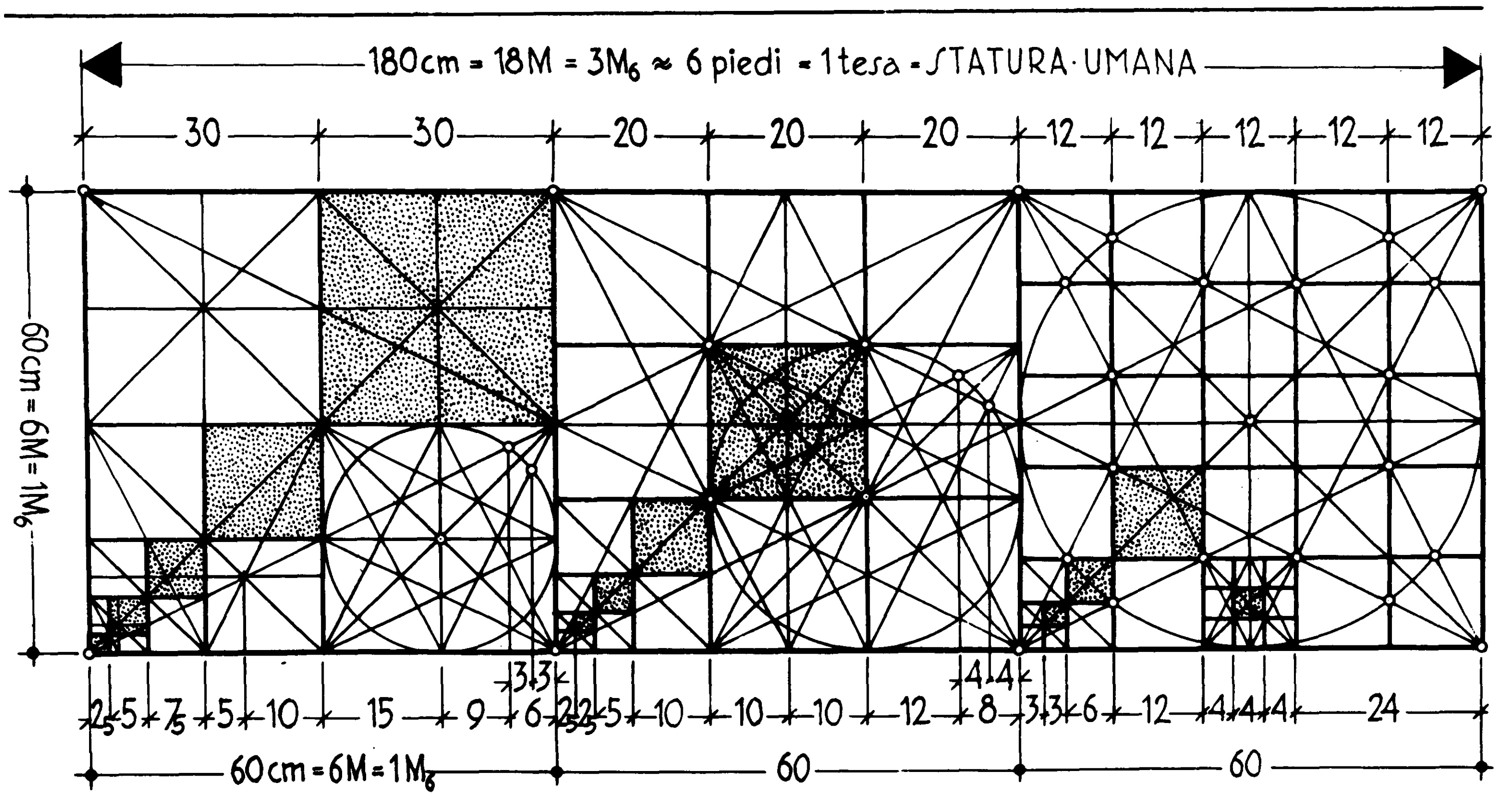


Plate No. 10

<u>60 CM to 6 M PROPORTION SYSTEM</u>
<u>Modular variations - one bay</u>

By: Milan Zlokovic

La Coordinazione Modulare Industrializzazione Dell' edilizia - Dedalo Libri, Bari - Italy Pg. 176

that provide for a flexible system of expression - that of music has provided a point of inspiration that will be elaborated upon. It is from the synthesis of this and previous structures that the authors have developed a fully integrated and flexible system of interchangeable spans for urban spaces. Just as the structure of music provides for harmony and beauty within the limited range of sounds discernable by man, so it should be provided for in the very structure of a unified city core building system. Where the spaces, transitions and elements are juxtaposed to each other, either in an ordered system which we are striving for; or into confused chaos which exists today - where compatibility and harmony is but a token gesture. Real beauty and harmony is disciplined, and it reveals itself from the inside outward. Therefore, it is an example to be reflected clearly - if the heart of the city reflects character, so will the outlying urban regions; but an example must be established.

3-A. The 12 Note Tonality System:

Here again we find the number 12 as the general common denominator of the structure. The structure of the 12 note tonality system has provided everyone of our great composers from Bach to Stravinsky to Mendelsohn, to create music of great depth and beauty. Their insight and discipline within the order established by the above system validates the principle of structure irrespective of the disciplines involved; whether it is music or architecture, the fundamental fabric remains consistent, irrespective of time, style, or climate.

The 12-Note Tonality System is composed of two interrelated sequential steps on a progressive series - ratio of 1:1/2. There are the following divisions:

a. Major Notes (7 tones) = C, D, E, F, G, A, B

b. Minor Notes (5 semitones) = C#, D#, F#, G#, A#

It should be noted that there is no E# or B# this gap is explained by the fact that the musical notes C and B# are equivalent elements, and F and E# are also equal. The change of one scale level to another occurs when you reach one complete cycle - or one octave, the same note, but at a new dimension. This concept validates another principle that one scale is appropriate to its function, and no other.

3-B. The Structure of Rhythm:

"If music is to be anything but indiscriminate sound there must be an ordered arrangement (1) of single sounds in succession, which is called melody (discussed under the 12-note tonality system); (2) of sounds in combination, which is called harmony; and (3) in a temporal association that constitutes rhythm." [7]

The immediate application delves into the rhythm of vertical and horizontal elements in any city system. How there is area or structure provided for various intensities in relation to different functions or activities. The relationship to music is very appropriate - for the concept of visual congruence is the very counterpart of rhythm, synchonization, juxtaposition, and overlap that is desired in a flexible building system.

The rhythm notation structure is the abstract relationship of proportion applied to music. It to has a variable structure which provides for permutations within given variables. The basic structure is as follows:

---

[7] Music by Enclycopedia Britannica Volume No. 15 William Benton Publisher, Chicago.

No:	Description:	Unit:
a.	Whole note	8/8 𝅝
b.	Seven-eighth's note	7/8 𝅗𝅥.‿♪
c.	Three-quarter note	6/8 𝅗𝅥.
d.	Five-eighth's note	5/8 𝅗𝅥‿♪
e.	Half note	4/8 𝅗𝅥
f.	Three-Eighth's note	3/8 ♩.
g.	Quarter note	2/8 ♩
h.	Eighth note	1/8 ♪

The above structure reinforces the concept of order and continuity within a city system; where the spaces may have the concept of continuity from the most private spaces (living areas) to the most intensive public spaces, from administrative, commercial, educational, and entertainment.

A clear example of this is shown in plate No. 11 where the frequency modulation series shows a constant frequency generated at several rates or rhythms. This picture clearly reinforces the concept of order and variation under a single harmonious context.

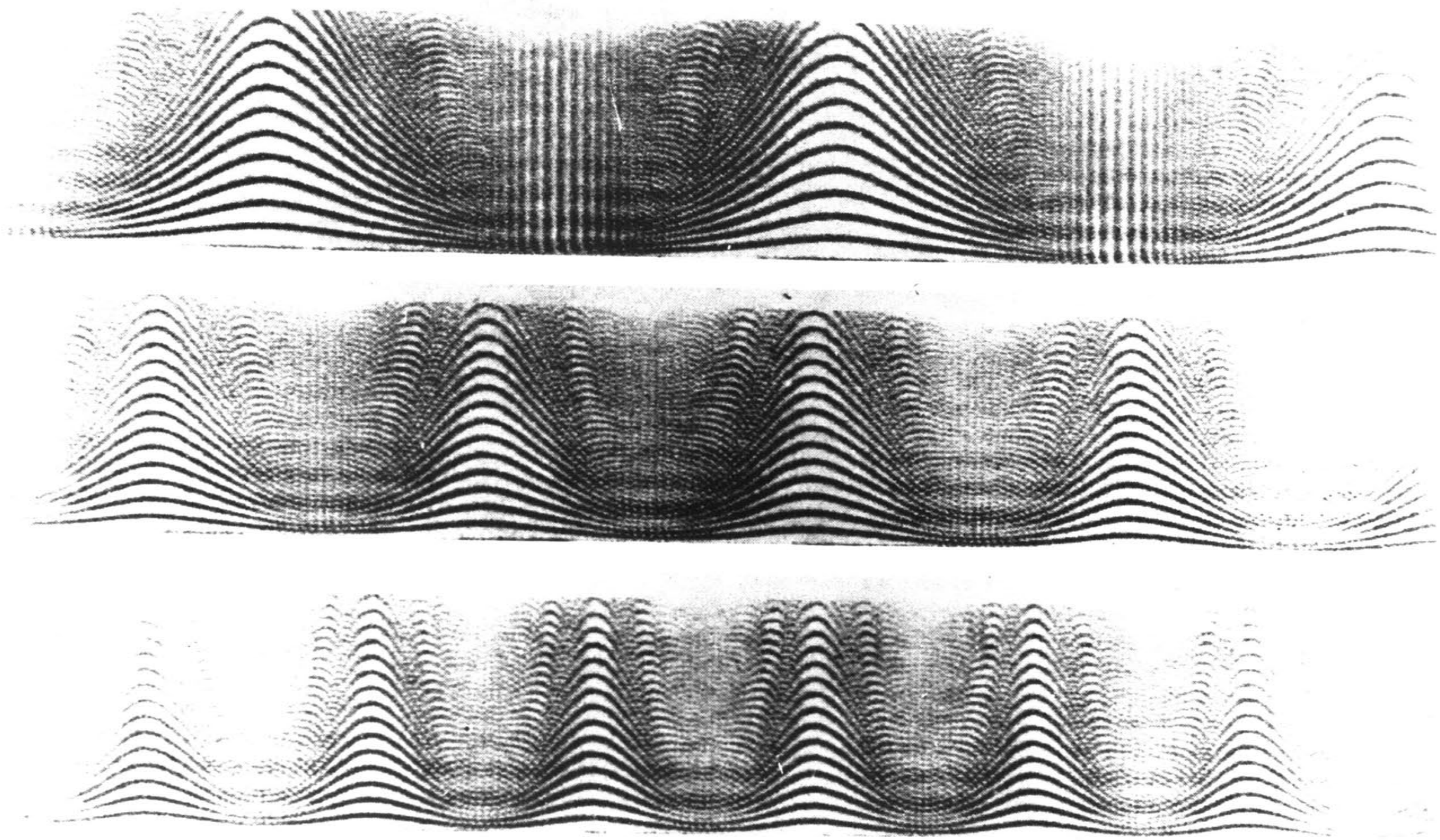


Plate No. 11

FREQUENCY MODULATION SERIES
Constant frequency at several rates
The New Landscape by Gyorgy Kepes Pg. 177

4. The Variable Scale Orders System:

Herein lies the final synthesis of the previous body of research into the structure of measurement, proportion and music for a variable scale order system for the city matrix structure. Plate no. 12 shows the scale order system based on all the major principles previously discussed; where it includes two major scales, either on the additive or doubling series, and compared proportionately to the octave (12 note) musical system. The purpose and function of this inter-related proportional system is its inherent ability to define space on an ordered level, and its ability to change scale proportionately throughout the whole system of spaces--from the smallest element requirements to the largest parameters for major city districts or zone areas. The real value of this proportional system comes in its consistent application as a design criteria over a collection of urban spores; where structure, horizontal and vertical circulation, services, and contiguous spores are correlated by a variable dimensional matrix system. It is this dimensional matrix system that is established "apriori", and all architectural solutions are required to maintain respect to this system, yet provided the freedom of variation within the limits of orthogonal geometry and the variable scale orders proportionate to the requirements needed. On Plate no. 13, an example of the Gothic mason's mark shows the historical reference point to spatial order and variation within a given geometrical context which provided for beauty and harmony.

VARIABLE SCALE ORDERS FOR THE CITY AS A SYSTEM : A = Additive & D = Doubling Series/Scale

12 NOTE / OCTAVE		SCALE 1-A	SCALE 2-A	SCALE 3-A	SCALE 4-A	SCALE 5-A	SCALE 6-A	SCALE 7-A	SCALE 8-A	SCALES:
Tonic	Sub-T.									
C		3' - 9"	7' - 6"	15' - 0"	30' - 0"	60' - 0"	120' - 0"	240' - 0"	480' - 0"	SCALE C-D
	C#/Db	5" - 7 1/2"	11'- 3"	22' - 6"	45' - 0"	90' - 0"	180' - 0"	360' - 0"	720' - 0"	SCALE C#-D
D		7' - 6"	15'- 0"	30' - 0"	60' - 0"	120'- 0"	240' - 0"	480' - 0"	960' - 0"	SCALE D-D
	D#/Eb	8' - 4 1/2"	18'- 9"	37' - 6"	75' - 0"	150'- 0"	300' - 0"	600' - 0"	1200'- 0"	SCALE D#-D
E		11'- 3"	22'- 6"	45' - 0"	90' - 0"	180'- 0"	360' - 0"	720' - 0"	1440'- 0"	SCALE E-D
F		15'- 0"	30'- 0"	60' - 0"	120'- 0"	240'- 0"	480' - 0"	960' - 0"	1920'- 0"	SCALE F-D
	F#/Gb	16'-10 1/2"	33'- 9"	67' - 6"	135'- 0"	270'- 0"	540' - 0"	1080'- 0"	2160'- 0"	SCALE F#-D
G		18'- 9"	37'- 6"	75' - 0"	150'- 0"	300'- 0"	600' - 0"	1200'- 0"	2400'- 0"	SCALE G-D
	G#/Ab	20'- 7 1/2"	41'- 3"	82' - 6"	165'- 0"	330'- 0"	660' - 0"	1320'- 0"	2640'- 0"	SCALE G#-D
A		22'- 6"	45'- 0"	90' - 0"	180'- 0"	360'- 0"	720' - 0"	1440'- 0"	2880'- 0"	SCALE A-D
	A#/Bb	24'- 4 1/2"	48'- 9"	97' - 6"	195'- 0"	390'- 0"	780' - 0"	1560'- 0"	3120'- 0"	SCALE A#-D
B		26'- 3"	52'- 6"	105'- 0"	210'- 0"	420'- 0"	840' - 0"	1680'- 0"	3360'- 0"	SCALE B-D
C		30'- 0"	60'- 0"	120'- 0"	240'- 0"	480'- 0"	960' - 0"	1920'- 0"	3840'- 0"	SCALE CC-D
	C#/Db	31'-10 1/2"	63'- 9"	127'- 6"	255'- 0"	510'- 0"	1020'- 0"	2040'- 0"	4080'- 0"	SCALE CC#-D

Plate No. 12 THE VARIABLE SCALE ORDER SYSTEM

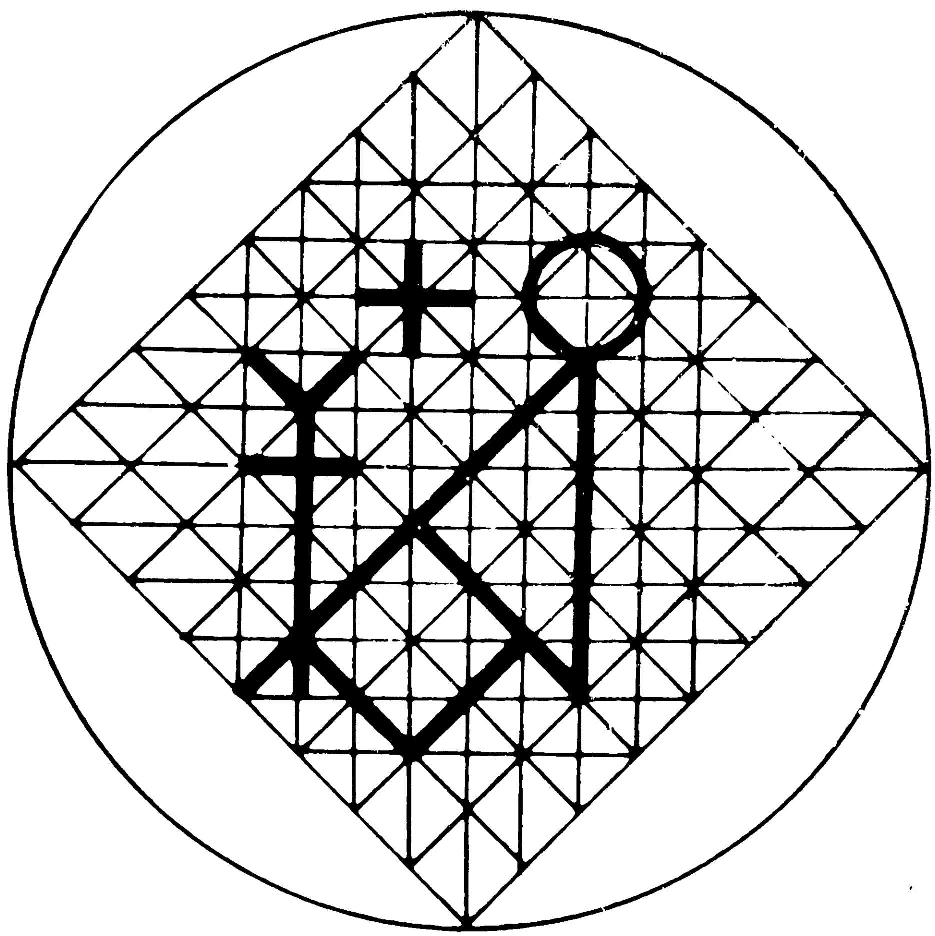


Plate No. 13 THE GOTHIC MASON'S MARK
The heavy lines represent the seal, and the thin lines represent the modular ground lattice -- infinite combinations.

The New Landscape by Gyorgy Kepes
Pg. 333

The Hierarchy of Structure:

In terms of specific principles regarding the limits and variations of spatial order for three dimensional forms, in the terse comment by Lancelot L. Whyte, noted English physicist:

> "The decade 1885-95 stands out in the history of science. For it is then proved, once and for all, that the equilibrium structure of every homogeneous crystal at a low enough temperature must correspond to one of 230 distinct types of symmetry. The 'must' is the direct consequence of the simplist conceivable assumptions applied to three-dimensional space. 230 types are possible, no more, no less, and no Einstein can ever question this, the most firmly established mathematical conclusion concerning anything in this three dimensional universe. Here the science of form has touched bottom. This is the paradigm for all knowledge of spatial form, because it is static and geometrical and exploits to the full the steric character of our space."

In order to reinforce the concept of a tremendous ecological hierarchy of structures where there is a gradually continuity of interlocking systems, let us look at the following set of recognizable systems:

No:	System:	Major Units:
1.	Atomic Nuclei	Protons, Neutrons
2.	Atoms	Nuclei, Electrons
3.	Simple Molecules	Atoms
4.	Complex Molecules	Atoms
5.	Liquids	Molecules
6.	Organisms	Sets of Atomic Groups
7.	Man	Family
8.	Solar System	Sun, Planets
9.	Galaxies	Stars
10.	The Universe	Galaxies

However, in spite of man's present state of vanity regarding his accomplishments, let's look at some old facts regarding his limitations.

Again, I have chosen Mr. Whyte's comments to show an overview of our position regarding order and principle within all disciplines, for obviously, within the confines of responsible architecture it is necessary to relate, not negate relationships properly.

1. "The analytical mind must ultimately come to order; and the form enthusiast come to earth and accept structure. For that is how this universe is made."

2. "Science is in an awkward situation. Knowledge has become a single stupendous web of facts, known to be multiply interconnected, but lacking appropriately powerful organizing ideas. The burden of uncoordinated facts is insupportable. Mathematics no longer unifies."

This brief discourse provides for a point of emphasis on the concept of real living laws, which when broken, provide for chaos, disorder, and confusion--irregardless of the scale level which it occurs at. When it occurs at the level of living cells and organisms, it produces cancer; and when disorder strikes social systems--war occurs; and when cities are overstructured physically, decay developes by providing us with slums and ghettos. Obviously, when a principle is broken, regardless of person or ignorance of that principle, it extracts a primitive adjustment--therefore, harmony reflects understanding of those principles (physical or otherwise). Isn't this enough argumentation to indicate the need for order, discipline, and control within the concept of The City as a System? We affirm that position--and our final city systems model emphasizes that approach.

Kepes, Gyorgy, Structure in Art and Science, M.I.T. Press, 1965, pp. 23, 25, 26.

THE CITY AS A SYSTEM - SPECIFIC DESIGN SOLUTION

By: David Kyun Hyun

Keun Sup Lee

General Definition of the Central City Program:

The purpose of the following program for a city of approximately 1,200,000 is to define the limits and general character of the problem.

The problem "endeavors to develop a network of a portion of a city as a system of circulation and structure." That portion of the city is within the context of the central civic core of a city supporting an urban population which has been established at the above figure.

However, in order to give the design criteria more validity and substance of that "CENTRAL CITY CORE" of a city, we have established the following framework, premise, and certain assumptions.

In order to establish a qualitative optimum gunctioning level of that told 1,200,000 population two various densities governing the heart of the city were considered. The first density level is premised on a resident population level of 120,000 (10%) for the central city, and 1,080,000 (90%) for the outlying urban fringe region. This is defined as Scheme 120.

The second density level is premised on a resident population level of 240,000 (20%) for the central city, and 960,000 (80%) for the outlying urban fringe area. This comparative alternative is defined as Scheme 290.

By providing two significant alternative density resolutions for a central city, a valid basis for selecting and comparing "permanent variables" may be established within the formulative stages of the design from regarding the City as a System.

The following program was given by the thesis advisor as a point of departure for the thesis. It was within this context that the program was initiated:

NETWORK OF A CITY AS A SYSTEM

Graduate Program - Section A

Professor Eduardo F. Catalano

General Statement:

The project endeavors to develop a network of a portion of a city as a system of circulation and structure. It may cover an area not less than a square mile and should incorporate the following elements:

a) "city blocks" (of orthoganal shape and of an area not smaller than 250,000 sq. ft. each.)

b) City "streets" for vehicles and pedestrians, joined or segregated, but expressed in 3 different intensities of flow as expressed in their widths.

c) Structural grid, expressed in several, modularly related spans; with location of basic service cores. The distance of the cores will be determined by fire regulations. See BOCA code.

d) Open areas for short span structures as needed for housing, motels, etc., with spans coordinated with the large span of the basic grill.

e) Transportation grid--cars, electric buses, subway, etc. Pedestrian paths.

f) Main and secondary utility grids feeding cores and capable of easy maintenance, and free from conflicts with other city services.

g) Determination of construction volume and its relation to density.

Presentation Requirements:

1. Plan of underground system (covering most of the chosen area).
2. Plan of ground floor system.
3. Plan of upper levels showing that the same grid can provide at least 5 different spatial solutions.
4. Plan showing in detail modular structural systems with changeable spans.

5. Two sections
6. Plan of utilities
7. Plan of cores
8. Model showing the basic components: utilities, transportation structure, cores.
9. Report

THE DESIGN METHODOLOGY

The major source of inpetus toward the direction of establishing a variable study model of the city as a system was via our thesis advisor, Professor Eduardo F. Catalano. His legistical influence, our decision to provide decisions based of critical evaluation of interrelated variables, and the setting of a technological environment (M.I.T.), provided the implementation of the Scientific Method for the development phase of establishing the city systems model.

In order to clarify the approach in its full theoretical structure, the following material was abstracted from a key reference which corroborated our basic approach - only after the bulk of our work, did we realize the noteworthiness of such complementary material.

The following is a definition of the Scientific Method which quickly summarizes our approach:

1. THE SCIENTIFIC METHOD:

   "By a scientific method we refer to the way techniques are selected in science that is, to the evaluation of alternative courses of scientific action. Thus, whereas techniques used by a scientist are results of his decisions, the way these decisions are made is the result of his decision rules. Methods are rules of choice techniques are the choices themselves."[3]

2. The fruits or benefits of such a process of analysis are the following:

   a. "It provides a basis for determining the extent to which any research is controlled, and, hence, scientific."

---

[3] Scientific Method-Optimizing Applied Research Decisions by Russel L. Ackoff, John Wiley & Sons, N. Y., 1962, p.6

b. "Together with the approximate theory it provides a basis for adjusting results obtained by use of less than the best known techniques so as to better approximate results that would have been obtained by use of the best known techniques."

c. "It makes explicit the kind of knowledge required to effectively adjust to the standard."[4]

3. The general types of questions that the <u>scientific method can answer</u>:

   a. <u>Form of Statements</u>:

      (a) Predication-classification

      (b) Comparative

      (c) Functional

   b. <u>Form of Expressions</u>:

      (a) Qualitative

      (b) Quantitative

   c. <u>Scope of Statements</u>:

      (a) Particular

      (b) General[5]

4. <u>The Breakdown of Applied Research Methodology</u>:

   a. Formulating the problem

   b. Constructing the model

   c. Testing the model.

   d. Deriving a solution from the model.

   e. Testing and controlling the solution

   f. Implementing the solution.[6]

   The limits of our thesis primarily covers the sequential process from A to D, and secondly from E to F.

---

[4]Ibid pp6-7

[5]Ibid pp6-9

[6]Ibid p26

5. The Nature of Problems:

The minimal necessary and sufficient conditions for the existence of a problem are as follows:

a. An individual who has a problem: a decision maker.

b. An outcome that is desired by the decision maker (i.e., an objective)

c. At least two unequally efficient courses of action which have some chance of yielding the desired objective. There must be a "real" difference between the choices available to the decision maker.

d. A state of doubt in the decision maker as to which choice is "best."

e. An environment or context of the problem. The environment consists of all factors which can effect the outcome and which are not under the decision makers control.[7]

6. Measures of Efficiency:

"There are several types of measure of efficiency, the definition of which requires the concepts of input and output. Input refers to the resources which are consumed or expended in taking a course of action. Output may be measured in turms of either the resources which result from taking the course of action or the psychological or sociological characteristic of the resulting state."

a. Specified output and input

b. Specified output and variable input

c. Variable output and specified input

d. Variable input and output[8]

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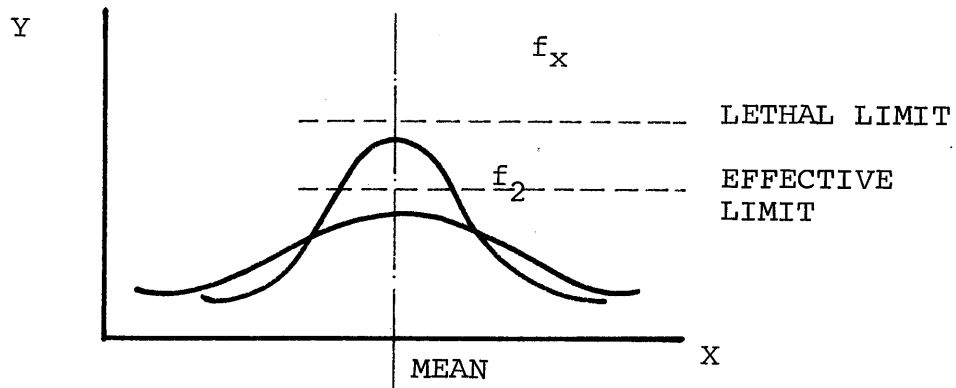
[7] Ibid p30

[8] Ibid p34

7. <u>Quantitative Objectives</u>:



TWO EFFICIENCY FUNCTIONS WITH EQUAL MEANS BUT UNEQUAL DISPERSIONS

"We observe first that two courses of action may have the same average efficiency but have different dispersion or spreads."
To select the best course of action it is also necessary to know the value function of the x-scale. In the above figure it should be noted that a value need not be monotonically increasing, as in f_x.
For example, the value of arsenic in a drug may increases the amount of arsenic increases up to a certain amount, but as it a lethal dose the value decreases."[9]
This analogy captures the essense of our study model of a city system given a limited area, but varying the distribution of the residential population to the core of the central city - there is an optimum limit we are striving to ascertain, beyond that, the circulation pattern percentages reach uneconomical proportions, and we contend that the visual volumetric order proceeds from order to chaos

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[9] Ibid p41

Conclusion:

The main point to consider is that our city systems model will only provide an approximation of the key interactions within a city context and how when one variable is changed in its input value, such as total population, what are the consequent values, or output of density per function, traffic circulation, land coverage, parking requirements, volumetric changes. Such a study model can be defined as an observational model - giving mirror images of all major changes within that system.

Basic Assumptions and Design Criteria:

In order to establish a critical network of a portion of city as a system of circulation, it was deemed necessary by the authors to extensively investigate the general requirements and basic assumptions for the city systems model. The following material and calculations endeavors to show the basic assumptions regarding population distribution and its consequent percentages in land area, volumetric requirements, land coverage, and parking densities, construction capabilities regarding growth.

It is important to state that the design process involved several stages in a large comprehensive effort, of which it becomes evident that time was lacking to synthesize it properly. However, stage 120 refers to the first stage and makes general first hand assumptions regarding the distribution of requirements for the ten major planning zones within the city system. The effort on stage 120 is comprehensive and is a dear effort and predicting all factors on an inter-related basis. The zoning maps included show graphically the representation of density according to the value pattern assigned it (each dot represent an equivalent numerical value--example, one dot equals 100 persons for residential population).

Then stage no. 240 was implemented as indicated in the design methodology to show conclusions for planar differentiation on the assumption of increased density or growth in the central city. The calculations involved were critical refinements of a non-linear basis for requirements in housing, commerical, and transportation. It was of immense value in restructuring the major elements of the city into a well defined interacting organism.

Also of significant value in the establishment of the design problem was the study into general city variations--central core city, linear city, poly-nucleated cities, and interdependent satellite cities. It was decided to evaluate the concept of the central city model because it reflected the most atypical system of most cities in existence today; secondly, because most current data on available U.S. Cities were based on this assumption; and finally, because it provided a basic premise for the application of this approach to computer program manipulation on the basis of matrix analysis methods.

The authors feel that this thesis bears the brunt of a design approach which is comprehensive, inter-related, and consistent--yet not without its own shortcomings. The main merits of this thesis lies in the process or methodology and not so much in the final product. It is for this reason that the major part of the design calculations and assumptions are included herein for future reference. The major weakness in this attempt lies in the shortcomings due to a weak initial definition of the final city system model desired and the brevity of the time requirements involved in the project.

GENERAL DESIGN ASSUMPTIONS
FOR CENTRAL CITY

CITY CENTER PROGRAM - JOB COMPOSITION FOR TOTAL CITY:
BASIC ASSUMTIONS FOR SCHEME 120 AND 240

	BASIC CATEGORY:	(%)	AMOUNT:
1.	Government Administration	10%	48,000
2.	Retail Trade	16%	76,500
2a.	Cultural/Ent.	3.4%	16,000
3.	Selected and Professional	6.6%	32,000
4.	Wholesale Trade	5%	24,000
5.	Health Services	3%	14,400
6.	Finance, Insurance and Real Estate	4%	19,200
7.	Communications and Utilities	3%	14,400
8.	Educational Services	12%	57,500
9.	Contract Construction	5%	24,000
10.	Manufacturing - Heavy	3.7%	18,000
11.	Manufacturing - Light	25%	120,000
	Parks and Recreation	1.3%	6,000
	Agriculture	2%	10,000
		100%	480,000 Persons

Note: above figures based on an assumed work force of 480,000 from a total population of 1,200,000.

JOB COMPOSITION FOR CENTRAL CITY DESIGN:					
NO.	CATEGORY	SCHEME NO. 120		SCHEME NO. 240	
P-1	Government Administra.	75%	36,000.	80%	38,000.
		25%	12,000.	20%	10,000.
B-1	Retail Trade	68%	52,000.	76%	58,000.
		32%	24,500.	24%	18,500.
B-1	Selected & Professional	50%	16,000.	63%	20,000.
		50%	16,000.	37%	12,000.
B-2	Wholesale Trade	66%	16,000.	75%	18,000.
		34%	8,000.	25%	6,000.
B-1	Health Services	42%	6,000.	55%	8,000.
		58%	8,400.	45%	6,400.
B-1	Finance, Ins. Real Estate	62%	12,000.	73%	14,000.
		38%	7,200.	27%	5,200.
P-5	Communica-tion & Util.	55%	8,000.	70%	10,000.
		45%	6,400.	30%	4,400.
P-3	Educational Services	55%	32,000.	62%	36,000.
		45%	25,500.	38%	21,500.
P-2	Cultural & Entertain.	62%	10,000.	75%	12,000.
		38%	6,000.	25%	4,000.
B-1	Contract Construc.	60%	14,000.	75%	18,000.
		40%	10,000.	25%	6,000.
---	Manufactur'g. Heavy	---	---	---	---
		100%	24,000.	100%	24,000.
B-2	Manufactur'g. Light	67%	80,000.	75%	90,000.
		33%	40,000.	25%	30,000.
---	Agriculture	---	---	---	---
		100%	10,000.	100%	10,000.
P-5	Parks & Recreation	50%	3,000.	66%	4,000.
		50%	3,000.	34%	2,000.
GRAND TOTAL:		100%	480,000.	100%	480,000.

Note: the above figures are for the central City - top line - outlying areas - bottom line.

Plate No. 14

Location of the General Workforce:

Assumptions for Scheme No. 120:

1. Workforce:	a. Central City	285,000	59%
	b. Sub-centers	195,000	41%
Sub-total:		480,000.	100%
2. Total resident population of:		120,000	persons
		36,000	D.U.
3. Total population during daytime:		357,000	persons

Assumptions for Scheme No. 240:

1. Workforce:	a. Central City	326,000	68%
	b. Sub-centers	154,000	32%
Sub-total:		480,000	100%
2. Total resident population of:		240,000	persons
		72,000	D.U.
3. Total population during daytime:		589,000	persons

Note: for every population unit of 120,000 persons it breaks down approximately:

a. Eligible persons	48,000	workforce
b. Wives, children & students + elderly	72,000	non-working
	120,000	total

TABLE NO. 15

Estimated Proportional Composition of Labor Force by Industry of Employment for Urban Areas

The following information was abstracted from the U.S. Bureau of the Census, U.S. Census of Population, 1950, Vol. IV, Special Reports - Part I, Chapter D, Industrial Characteristics. Table 1.

1. Retail

a.	Eating and Drinking Places	20%
b.	Food Stores except dairy products	18%
c.	General Merchandise Stores	11%
d.	Motor Vehicles and Accessories	6%
e.	Apparel Stores	6%
f.	Others	39%
	Sub-Total:	100%
	Percentage of Total:	15%

2. Business & Personal Services

a.	Private Households	30%
b.	Auto Repair Services	12%
c.	Laundry, Cleaning and Dyeing	12%
d.	Hotels and Lodging Places	10%
e.	Entertainment and Recreation	9%
f.	Others	27%
	Sub-Total:	100%
	Percentage of Total:	10%

3. Professional Services

a.	Educational Services, Government	33%
b.	Hospitals	22%
c.	Medical and Health Services	14%
d.	Educational Services, Private	11%
e.	Welfare and Religious Services	8%
f.	Legal Services	5%
g.	Others	7%
	Sub-Total:	100%
	Percentage of Total:	8%

4. <u>Finance, Insurance and Real Estate</u>

a.	Insurance	42%
b.	Banking	29%
c.	Real Estate	29%
	Sub-Total:	100%
	Percentage of Total:	3%

5. <u>Wholesale</u>

a.	Motor Vehicles and Equipment	19%
b.	Food and Related Products	6%
c.	Others	75%
	Sub-Total:	100%
	Percentage of Total:	16%

6. <u>Public Administration</u>

a.	Federal Public Administration	41%
b.	Local Public Administration	31%
c.	State Public Administration	11%
d.	Postal Service	18%
	Sub-Total:	100%
	Percentage of Total:	4%

7. <u>Transportation, Communication & Utilities</u>

a.	Transportation		67%
	(1) Railroad, Railway Express	48%	
	(2) Street Railways	8%	
	(3) Taxis, Trucking	13%	
	(4) Others	31%	
	Sub-Total:	100%	
b.	Communications		15%
c.	Utilities		18%
	Sub-Total:		100%
	Percentage of Total:		8%

8. Manufacturing

a. Durable Goods			53%
	(1) Metal Industries	25%	
	(2) Transportation Equipment	18%	
	(3) Machinery	16%	
	(4) Primary Metals	15%	
	(5) Others	26%	
	Sub-Total:	100%	
b. Non-Durable Goods			47%
	(1) Apparel	25%	
	(2) Food and Kindred Products	21%	
	(3) Textile Mills	18%	
	(4) Chemicals	10%	
	(5) Others	26%	
	Sub-Total:	100%	100%
	Percentage of Total:		28%

9. Other Industries

a. Construction		76%
b. Mining		12%
c. Agriculture, Forestry, Fisheries		12%
	Sub-Total:	100%
	Percentage of Total:	8%

GRAND TOTAL: 100%

The Location of Residences and Work Places in Urban Areas by Louis K. Loewenstein, pp. 272 - 273 (The Scarecrow Press, Inc., New York, 1965).

COMPREHENSIVE DESIGN CALCULATIONS FOR SCHEME NO. 120

RESIDENTIAL ZONE AREAS - SCHEME 120

DESIGN CRITERIA AND CALCULATIONS:

R-1 Single Family Residential District

Type: Single Family Detached Residences

Percent: 25% of Total Population in Center City

Total No. of People in R-1 District

$$120{,}000 \times \frac{25}{100} = 30{,}000 \text{ People}$$

Average Person/Family: 4 Person/D.U. (Dwelling Unit)

Total No. of D.U. $\frac{30{,}000}{4}$ = 7,500 D.U.

Total No. of Block: 128 Block = 66,355,200 Sq. Ft.

= 1,523,305 Acres = 2.380 Sq. Miles

Average Lot Size/D.U.: (included streets) $\frac{66{,}355{,}200}{7{,}500}$ = 8,850 Sq. Ft.

No. of D.U/Acre: $\frac{7{,}500 \text{ D.U.}}{1{,}523 \text{ Acre}}$ = 4.9 D.U./Acre

No. of People/Acre: 4.9 x 4 = 19.6 People/Acre

No. of Family/Block: $\frac{7{,}500 \text{ D.U.}}{128}$ = 58.5 D.U./Block

No. of People/Block: 58.5 x 4 = 234 People

Average No. of Cars/D.U.: 1.5 Cars/D.U.

Total No. of Cars: 1.5 x 7,500 = 20,000 Cars

Total No. of Cars/Acre: 20,000/1,523 = 6.5 Cars/Acre

Total No. of Cars/Block: 26,000/128 = 156 Cars/Block

Total Sq. Ft. of Parking Space: 20,000 x 400 Sq. Ft.

= 8,000,000 Sq. Ft.

Total Sq. Ft. of Parking Space/Block: $\frac{8{,}000{,}000}{128}$ = 62,500 Sq. Ft.

Percent of Parking Area of Block: $\frac{62{,}500 \times 100}{518{,}400}$ = 12%

Average Building Size: 1,600 (one story)/D.U.

Total Building Coverage Area in Sq. Ft./Block:

$$\frac{1{,}600 \text{ Sq. Ft.}}{\text{D. U.}} \times 58.5 = 93{,}500 \text{ Sq. Ft.}$$

Total Building Coverage Percent of Block: $\frac{93{,}500 \times 100}{518{,}400} = 18\%$

Total Floor Area/Block: 93,500 Sq. Ft.

Percent of Street: 15%

Percentages:
1. Building Coverage = 18%
2. Parking Space = 12%
3. Streets and Circulation = 15%
4. Open Space = 55%

Permissible Usage: None

R-2 Multiple Family Residential District

Type: Single Family Attached Residences (Townhouse)

Percent: 30% of Total Population in Center City

Total No. of People in R-2 District:

12,000 x 30/100 = 36,000 People

Average Person/D.U.: 3.5 Person/D.U.

Total No. of D.U.: 36,000/3.5 = 10,300 D.U.

Total No. of Block: 84 Blocks = 43,545,600 Sq. Ft.

= 999.669 Acres

= 1.561 Sq. Miles

Average Lot Size/D.U.: 43,545,600 Sq. Ft./10,300 D.U.

= 4,220 Sq. Ft. (Streets are Included)

No. of D.U./Acre: $\frac{10{,}300 \text{ D.U.}}{999.669 \text{ Acres}} = 10.3$ D.U./Acre

No. of People/Acre: 10.3 x 3.5 = 36 People/Acre

No. of D.U./Block: 10,300/84 = 123 D.U./Block

No. of People /Block: 36,000/84 = 430 People/Block

Average No. of Cars/D.U.: 1.0 Cars/D.U.

Total No. of Cars: 1.0 x 10,300 D.U. = 10,300 Cars

Total No. of Cars/Acre: 10,300/999.669 = 10.3 Cars/Acre

Total No. of Cars/Block: 10,300/84 = 123 Cars/Block

Total Sq. Ft. of Parking Space: 10,300 Cars x 400 Sq. Ft./Car

= 4,120,000 Sq. Ft.

Total Sq. Ft. of Parking Space/Block: 4,120,000/84 = 49,000 Sq. Ft.

Percent of Parking Area of Block: $\frac{49,000 \times 100}{518,400} = 9.5\%$

Average Building Size: 700 Sq. Ft. (assumed two stories building)/D.U.

Total Building Coverage Area in Sq. Ft./Block: 700 x 123

= 86,100 Sq. Ft.

Total Building Coverage Percent of Block: $\frac{86,100}{518,400} \times 100 = 16.6\%$

Percent of Street: 12%

Percentages:
1. Building Coverage = 16.6%
2. Parking Space = 9.0%
3. Streets & Circulation = 12.0%
4. Open Space = 62.0%

Permissible Usage: Nursery School

Kindergarten

Community Center

Church

Park, Golf Course

R-3 High Density Multiple Family Residential District

Type: Multiple Family Apartments--walk up apartment, high rise

Percent: 45% of Total Population in Center City

Total No. of People in R-3 District: $120,000 \times \frac{45}{100} = 54,000$ People

Average Person/Family: 3.0 Person/D.U.

Total No. of D.U.: 54,000/3 = 18,000 D.U.

Total No. of Blocks: 32 Blocks

R-3A--12 Blocks in the Core = 6,220,800 Sq. Ft. = 142.809 Acres

= .223/Sq. Miles

R-3B--20 Blocks in the Core Fringe = 10,368,000 Sq. Ft. = 238.016 Acres

= .371 Sq. Miles

A. R-3A--45% of D.U. in R-3 District

Total Units in R-3A District: $18,000 \times \frac{45}{100} = 8,100$ D.U.

Percentage Breakdown Units:

%	Type	Area	No. of D.U.	Sub-Total
25%	Efficiency	600	2,020	1,020,000 Sq. Ft.
40%	One Bedrm.	650	3,240	2,100,000 Sq. Ft.
25%	Two Bedrm.	900	2,020	1,818,000 Sq. Ft.
10%	Three Bedrm.	1100	1,720	1,900,000 Sq. Ft.
	Sub-Total:		8,100	6,838,000 Sq. Ft.
	15% of Circulation and Cars:			1,020,000 Sq. Ft.
	Total Floor Area:			7,858,000 Sq. Ft.

Floor Area/Block: 7,858,000/12 = 650,000 Sq. Ft./Block

Average Lot Size/D.U.: 6,220,800/8,100 = 765 Sq. Ft./D.U.

No. of D.U./Acre: $\frac{8,100 \text{ D.U.}}{142.809}$ = 57 D.U./Acre

No. of People/Acre: 57 x 3 = 171 Person/Acre

No. of Family/Block: $\frac{8,100 \text{ D.U.}}{12}$ = 675 D.U./Block

No. of People/Block: 675 x 3 = 2,025 Person/Block

Average No. of Cars/D.U.: 0.75

Total No. of Cars: 0.75 x 8,100 = 6,100 Cars

Total No. of Cars/Acre: 6,100/142 = 42.8/Acre

Total No. of Cars/Block: 6,100/12 = 510 Cars/Block

Total Sq. Ft. of Parking Space: 6,100 x 350 = 2,140,000 Sq. Ft.

Total Sq. Ft. of Parking Space/Block: 510 x 350 =

178,000 Sq. Ft./Block

Percent of Parking Area of Block: $\frac{178,000}{518,400}$ = 34.5%

A[1]. R-3A-1 (Walk Up Apartment 3 Stories Maximum)

Building Coverage/Block: 650,000/3 Stories = 216,700 Sq. Ft.

Percent of Building Coverage: $\frac{216,700 \times 100}{518,400}$ = 42%

Total Floor Area/Block: 650,000 Sq. Ft./Block

Percentages R-3A-1:
1. Building Coverage = 42%
2. Parking Space = 0 (34.5% Underground)
3. Streets & Circulation = 10%
4. Open Space = 48%

A[2]. R-3A-2 (Combination of Walk Up Apartment and Apartment High Rise)

50%--Walk Up Apartment (Average 3 Stories)

50%--High Rise (Average 16 Stories)

Building Coverage/Block: $\frac{(650,000)}{2}/3 + \frac{(650,000)}{2}/16$

= 325/3 + 325/16 = 108 + 20.4 = 128,400 Sq. Ft.

Percent of Building Coverage: $\frac{128,400 \times 100}{518,400}$ = 25%

Total Floor Area/Block: 650,000 Sq. Ft./Block

Percentages R-3A-2:
1. Building Coverage = 25%
2. Parking Space = 0 (34.5 Underground)

3. Streets & Circulation = 10%

4. Open Space = 55%

A[3]. R-3A-3 (High Rise Apartment--Average 16 Stories):

Building Coverage/Block: $\frac{650,000}{16}$ = 40,600 Sq. Ft.

Percent of Building Coverage: $\frac{40.600 \times 100}{518,400}$ = 7.8%

Total Floor Area/Block: 650,000 Sq. Ft./Block

Percentages R-3A-3:
1. Building Coverage = 7.8%
2. Parking Space = 20% (14.5% Underground)
3. Streets & Circulation = 8%
4. Open Space = 64.2%

Permissible Usage: Office, neighborhood center, church, commerce, elementary school

B. R-3B--55% of D.U. in R-3 District

Total Units in R-3B District: 18,000 D.U. x $\frac{55}{100}$ = 9,900 D.U.

Percentage Breakdown Units:

%	Type	Area	No. of D.U.	Sub-Total
15%	Efficiency	500	1,480	740,000 Sq. Ft.
40%	One Bedrm.	750	3,980	2,970,000 Sq. Ft.
30%	Two Bedrm.	1000	2,960	2,960,000 Sq. Ft.
15%	Three Bedrm.	1200	1,480	1,780,000 Sq. Ft.
	Sub-Total:		9,900	8,450,000 Sq. Ft.

15% of Circulations & Cars, Cores, Serv. 1,270,000 Sq. Ft.

Total Floor Area: 9,720,000 Sq. Ft.

Floor Area/Block: 9,720,000/20 = 486,000 Sq. Ft./Block

Average Lot Size/D.U.: $\frac{10,368,000}{9,900}$ = 1,050 Sq. Ft./D.U.

No. of D.U./Acre: 41.6 x 3 = 124.8 Person/Acre

No. of Family/Block: $\frac{9,900 \text{ D.U.}}{20}$ = 4.95 D.U./Block

No. of People/Block: 495 x 3 = 1,485 Person/Block

Average No. of Cars/D.U.: 0.75

Total No. of Cars: 0.75 x 9,900 = 7,420 Cars

Total No. of Cars/Acre: 7,400/238 = 31.2 Cars/Acre

Total No. of Cars/Block: 7,420/20 = 371 Cars/Block

Total Sq. Ft. of Parking Space: 7,420 x 350 = 2,600,000 Sq. Ft.

Total Sq. Ft. of Parking Space/Block: 371 x 350 = 130,000 Sq. Ft.

Percent of Parking Area of Block: $\frac{130,000 \times 100}{518,400}$ = 25%

B[1]. R-3B-1 (Walk Up Apartment 3 Stories Maximum)

Building Coverage/Block: 486,000/3 = 162,000 Sq. Ft.

Percent of Building Coverage: $\frac{162,000}{518,400}$ = 31.3%

Total Floor Area of Block: 486,000 Sq. Ft./Block

Percentage R-3B-1:
1. Building Coverage = 31.3%
2. Parking Space = 10 Surface Parking (15% Underground Park.)
3. Streets & Circulation = 10%
4. Open Space = 48.7%

B[2]. R-3B-2 (Combination of Walk Up Apartment & Apartment High Rise).

60%--Walk Up Apartment (average 3 stories)

40%--High Rise Apartment (average 8 stories)

Building Coverage/Block: $(486,000 \times \frac{60}{100})/3 + (496,000 \times \frac{40}{100})/8$ = 291.6/3 + 194.4/8 = 97 + 24.3 = 121.300 Sq. Ft.

Percent of Building Coverage: $\frac{121,300 \times 100}{518,400}$ = 23.4%

Total Floor Area of Block: 486,000 Sq. Ft./Block

Percentages R-3B-2:	1.	Building Coverage	=	23.4%
	2.	Parking Space	=	15% Surface Parking (10% Underground Park.)
	3.	Streets & Circulation	=	10%
	4.	Open Space	=	51.6%
				100%

B[3]. R-3B-3 (High Rise Apartment--Average 8 Stories)

Building Coverage/Block: 486,000/8 = 60,750 Sq. Ft.

Percent of Building Coverage: $\frac{60,750}{518,400} = 11.7\%$

Percentage R-3B-3:	1.	Building Coverage	=	11.7%
	2.	Parking Space	=	15% (10% Under.)
	3.	Streets & Circulation	=	8%
	4.	Open Space	=	65.3%

Permissible Usage: Office, Commerce, Elementary School, Junior High School, Senior High School, Neighborhood Center, Church, Post Office, Fire Station.

B-1 <u>Commercial and Business District - Scheme 120</u>

Basic Assumption: 50% of people (visitors and employees)use their own cars and 50% of people use transit.

Type: General Commerce and Business Area

Total No. of Blocks: 48 Blocks (8.33% of Total Land Area in Center City)

Permissible Usage:

Type Employment	No. of Employees	Aver. Sq. Ft. / Employee	Required Floor Area in Sq. Ft.
Retail Trade	52,000	600	31,200,000
Selected and Professional	16,000	400	6,400,000
Finance, Insurance, Real Estate	12,000	400	4,800,000
Contract Construction	14,000	200	2,800,000
Wholesale Trade	16,000	1.500	24,000,000
TOTAL:	110,000		69,200,000

Average Sq. Ft./Employee in C.B.D.: 69,200,000/110,000

= 625 Sq. Ft./Employee

Average No. of Employee/Block: 110,000/48 = 2300 Employee/Block

Average Floor Sq. Ft./Block: 69,200,000/48 = 1,440,000

Average Floor Area Ratio (F.A.R.): 1,440,000/518,400/518,400

= 2.78

Note: 5% of maximum total floor area in C.B.D. could be located in R-3 district, and vice versally 10% of total floor area in R-3 district could be mixed use in C.B.D. area.

Example: Apartment and Office Complex Towers

69,200,000 x 5/100 = 3,460,000 Sq. Ft.

could be located in mixed use in R-3 district.

Example: 10% of R-3A -- 785,000

10% of R-3B -- 972,000

TOTAL: 1757,000 Sq. Ft.

Total Units: 1757,000/800 = 2,188 units in C.B.D.

2,188 units could be located in B-1 district.

Total units in B-1 district: 2,188 units (10% of R-3)

Average Person/D.U. : 3

Total No. of Persons in C.B.D.: 2,188 x 3 = 6,564

No. of D.U./Acre: 2,188/558,420 = 3.9

No. of People/Acre: 3.9 x 3 = 23.7

No. of D.U./Block: 2,188/48 = 45.6

No. of People/Block: 45.6 x 3 = 136.8

Requirements of Residential Parking in C.B.D. District:

Average No. of Cars in C.B.D. Area/D.U.: 0.75

Total No. of Cars: 0.75 x 2,188 = 1,640

Requirements of Commercial and Business Parking in C.B.D. District:

Assumption: 1.5 Employee/Car

	% of Employees Using Auto	No. of Employees Using Car	No. of Visitors Car	Aver. Sq. Ft./ Car	Floor Area	No. of Cars
Retail Trade	50%	17,300	107,300	250	31,200,000	125,000
Selected & Professional	50%	5,300	13,000	350	6,400,000	18,300
Finance, Insurance	50%	4,000	12,000	300	4,800,000	16,000
Contract Construction	50%	4,700	4,600	300	2,800,000	9,300
Wholesale trade	50%	5,300	10,700	1,500	24,000,000	16,000
TOTAL:		35,600	147,600		69,200,000	183,000

Average Sq. Ft. in C.B.D./Car: 69,200,000/183,700 = 376

Total No. of Cars Requirement in C.B.D.: 183,600

Proposed Parking Requirement in C.B.D.:

1. Requirements of commercial and business parking in C.B.D.

   30% of parking requirements in C.B.D. area is provided at the periphery boundary parking garage:

   $$183{,}600 \times \frac{30}{100} = 55{,}000$$

   Total No. of Cars: 183,600 - 55,000 = 128,600

   No. of Cars/Block: 128,600/48 = 2,680

2. Total No. of parking requirements including both commercial and business plus residential district:

   128,600 + 1,640 = 130,240

   Average No. of Parking/Block: 130,240/48 = 2,740

   Sq. Ft. of Parking Space/Block: 2,740 x 356 = 960,000

   % of parking coverage: 960,000 x 100/518,400 = 185% (two levels of parking)

Maximum Building Coverage: 50%

518,400 x 50/100 = 260,000 Sq. Ft. Land Coverage/Block

Average Building Stories in C.B.D.: 1,440,000/260,000 = 5.5 Stories

Note: Permissible usage other than above mentioned; Maximum of 10% of Total Floor Area Required in C.B.D. (Hotel, Motel, Restaurant, Entertainment.)

B-2 <u>Light Manufacturing District</u>

Type: All activities concerned with the production or fabrication of goods, and/or activities involving the use of heavy equipment, such as printing presses.

Total Employees: 80,000

Average No. of Employees/ Block: 80,000/48 = 1,660

Average Sq. Ft./Employees: 500

Required Floor Area: 80,000 x 500 = 40,000,000

Floor Area/Block: 40,000,000/48 = 830,000

F.A.R.: 830,000/518,400 = 1/6

Average Requirement of Sq. Ft./Car: 600 Sq. Ft./Car

Total No. of Cars: 64,000,000/1000 = 64,000

No. of Cars/Block: 64,000/48 = 1,330

Sq. Ft. of Parking Area/Block: 1,330 x 350 = 465,000

% of Parking Coverage: 465,000 x 100/518,400 = 90%
(1 level parking)

Maximum Building Coverage: 60%

Building Coverage in Sq. Ft./Block: 518,400 x $\frac{60}{100}$ = 310,000

Average Building Stories: 830,000/310,000 = 2.67 Stories

*GENERAL PUBLIC SERVICES - SCHEME 120

P-1 <u>Government Administration - Scheme 120</u>:

Type: City Hall, Post Office, Federal Office, State Office, Municipal Office

Total No. of Blocks: 28 Blocks (4.86% of Total Land Area in Center City)

Total No. of Employees: 36,000

Average No. of Employees/Block: 36,000/28 = 1,280

Average Sq. Ft./Employee: 200

Required Floor Area: 36,000 x 200 = 7,200,000

Floor Area/Block: 7,200,000/28 = 257,000

F.A.R.: 257,000/518,400 = .496

Required Average Sq. Ft./Car: 400

Total No. of Cars: 7,200,000/400 = 18,000

No. of Cars/Block: 18,000/28 = 640

Sq. Ft. of Parking Space/Block: 640 x 350 = 224,000

% of Parking Coverage/Block: 224,000/518,400 = 43%

Maximum Building Coverage: 30%

Building Coverage in Sq. Ft./Block: $518,400 \times \frac{30}{100} = 155,000$

Average Building Stories in P-1 District: 257,000/155,000 = 1.65

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*Basic Assumption: 50% of People use Auto and
50% of People use Mass Transit

P-2 Cultural and Other Non-Profit Institutions

Type: Civic Auditorium, Theatre, Library, Museum of Art, Museum of Science, Health Service

Total No. of Blocks: 16 Blocks (2.77% of Total Land Area in Center City)

Total No. of Employees: 16,000

Average No. of Employees/Block: 16,000/16 = 1,000

Average Sq. Ft./Employee: 800

Required Floor Area: 800 x 16,000 = 12,800,000

Floor Area/Block: 12,800,000/16 = 800,000

F.A.R.: 800,000/518,400 = 1.54

Required Average Sq. Ft./Car: 1,000

Total No. of Cars: 16,000,000/1,000 = 16,000

No. of Cars/Block: 16,000/16 = 1,000

Total Sq. Ft. of Parking Area/Block: 1,000 x 350 = 350,000

% of Parking Coverage/Block: 350,000/518,400 = 67.5

Maximum Building Coverage: 40%

Building Coverage in Sq. Ft./Block: 518,400 x $\frac{40}{100}$ = 208,000

Average Building Stories in P-2 District: 800,000/208,000 = 3.85

P-3 Educational Institutions

Type: Elementary School, Junior, Senior High School, Colleges

Total No. of Blocks: 28 Blocks (4.86% of Total Land Area in Center City)

Total No. of Employees: 32,000

Average No. of Employees/Block: 32,000/28 = 1,140

Average Sq. Ft. of Floor Area/Employees: 1,200

Total Required Floor Area: 1,200 x 32,000 = 38,400,000

Note: 30% of above total required floor area is located within Residential District.

38,400,000 x 30/100 = 11,500,000 Sq. Ft.

Floor Area Distributed in P-3 District: 38,400,000 - 11,500,000 = 26,900,000

Floor Area/Block: 26,900,000/28 = 960,000

F.A.R.: 960,000/518,400 = 1.85

Required Average Sq. Ft./Car: 1000

Total No. of Cars: 26,900,000/1000 = 26,900

No. of Cars/Block: 960,000/1000 = 960

Sq. Ft. of Parking Space/Block: 960 x 350 = 336,000

% of Parking Coverage/Block: 336,000/518,400 = 65

Maximum Building Coverage: 40%

Building Coverage in Sq. Ft./Block: 518,400 x $\frac{40}{100}$ = 208,000

Average Building Stories in P-3 District: 960,000/208,000 = 4.6

P-4 Communications and Utilities

Type: Parking Facility, Subway Stations, Bus Terminals, Gas Stations, Utilities Service

Total No. of Blocks: 24 Blocks (4.16% of Total Land Area in Center City)

Total No. of Employees: 8,000

Average No. of Employees/Block: 8,000/24 = 333

Note: Additional 17% of above land area is distributed in random all over the Center City and 24 blocks of land area is devoted to the 2 levels of parking garage

Total No. of Cars Parking: 2 x 12,441,600/350 = 71,000

No. of Cars Parking/Block: 71,000/24 = 2,950

Note: 55,000 Cars--C.B.D.Area

16,000 Cars--Other than C.B.D. Area

P-5 Recreation, Parks, and Open Space

Type: Public Park, Zoo, Open Space

Total No. of Blocks: 140 Blocks (24.4% of Total Land Area in Center City)

Total No. of Employees: 3,000

Average No. of Employees/Block: 3,000/140 = 21.4

Requirements of Average Sq. Ft./Car: 10,000

Total No. of Cars: 7,257

No. of Cars/Block: 7,257/140 = 52

PARKING DENSITY STUDY-SCHEME 120:

Study 1: 50% of people (employees and visitors) use auto and 50% of people use mass transit.

Total No of parking space in Center City:

A. Residential

District R-1 --20,000

R-2 --10,000

R-3A-- 6,100

R-3B-- 7,820

Sub Total: 43,820

B. Business and

Comm District B-1--130,340

B-2-- 64,000

Sub Total: 247,000

C. Public Service

District P-1--18,000

P-2--16,000

P-3--26,900

P-4--71,000

P-5-- 7,257

Sub Total 139,157

Grand Total: 430,677 Cars in the Center City

Study 2: 35% of people (employees and visitors) use auto and 65% use mass transit

Total No of parking space in Center City:

A. Residential R-1 --20,000

R-2 --10,300

R-3A-- 6,100

R-3B-- 7,420

Sub Total 43,820

B. Business &

Comm District B-1--130,340 x 70/100 =

91,000/48

B-2--64,000 x 70/100 = 44,800

Sub Total: 930/Block

173,390

C. Public Service District

P-1--18,000 x 70/100 = 12,000
P-2--16,000 x 70/100 = 11,200
P-3--26,900 x 70/100 = 18,830
P-4--71,000 x 70/100 = 49,700
P-5--7,257 x 70/100 = 5,080

Sub-Total 97,401

Grand-Total: 314,620

Study 3: 20% of people use auto and 80% of people use mass transit

Total No. of parking spaces in Center City:

A. Residential District

R-1 --20,000
R-2 --10,300
R-3A-- 6,100
R-3B-- 7,420

Sub Total 43,820

B. Business and Comm. District

B-1--183,700 x .6 = 110,220
B-2--64,000 x .6 = 38,400

Sub Total: 148,620

C. Public Service District

P-1--18,000 x .6 = 10,000
P-2--16,000 x .6 = 9,600

P-3--26,000 x .6 =
15,600
P-4--71,000 x .6 =
42,600
P-5-- 7,257 x .6 =
4,356

Sub total: 82,956

Grand Total: 275,396 Cars in the Center City.

APPROXIMATE CALCULATIONS FOR STREET CIRCULATION TO AVAILABLE LAND USE PERCENTAGES :

For the Central City:

1. TOTAL AREA :

   a. Blocks (24) at 720'-0" each = 17',280'-0"

   B. Streets:

      B-1. Local Streets (16) at 60'-0" each
      = 960'-0"

      B-2. Collector Streets (4) at 120'-0" each
      = 480'-0"

      B-3. Major Arterials (3) at 150'-0" each
      = 450'-0"

      B-4. Freeway (2)at 180'-0" each
      = 360'-0" - perimeter of city.
      SUBTOTAL = 2,250'-0" width.

   C. TOTAL LENGTH = 17,280'-0" + 2,250'-0" = 19,530'-0"

      AREA = 380,000,000 Sq. Ft.
      8,750 Acres
      13.800 Sq. Miles

2. PROPOSED LAND PERCENTAGES:

2-a. Available land	= 80%
2-b. Circulation	= 20%
Total:	100%

3. CURRENT LAND PERCENTAGES:

3-a. Available land	= 70%
3-b. Circulation	= 30%
Total:	100%

SCHEME 120 - ZONING AREAS (Pop. = 120,000 Residents) 1 = Core Only / 2 = Core Fringe / 3 = Total Central City

ZONE	NO.	FUNCTION		NO. OF BLOCKS 518,400 S. F.	%	LAND AREA (SQ. FT.)	LAND AREA (AC.) (43,560 Sq. Ft.)	LAND AREA (SQ. MI.) (27,878,400 Sq. Ft.)
P-1	1	Administration Public Services	1	28	100.00%	14,515,200	333.223	.520
			2					
			3	28	4.86%	14,515,200	333.223	.520
B-1	2	Commerce and Business	1	48	100.00%	24,883,200	558.420	.892
			2					
			3	48	8.33%	24,883,200	558.420	.892
P-2	3	Cultural and Entertainment	1	16	100.00%	8,294,400	190.413	.297
			2					
			3	16	2.77%	8,294,400	190.413	.297
P-3	4	Educational Facilities	1					
			2	28	100.00%	14,515,200	333.223	.520
			3	28	4.86%	14,515,200	333.223	.520
B-2	5	Industry and Manufacturing	1					
			2	48	100.00%	24,883,200	558.420	.892
			3	48	8.33%	24,883,200	558.420	.892
see R1 to 3	6	Housing and Residential	1	12	5.00%	6,220,800	142.809	.223
			2	232	95.00%	120,268,800	2,760.991	4.314
			3	244	42.36%	126,489,600	2,903.801	4.537
P-4	7	Communications & Transportation	1					
			2	24	100.00%	12,441,600	285.619	.446
			3	24	4.16%	12,441,600	285.619	.446
	8	SUB-TOTAL:	1	104	18.00%			
			2	332	57.60%			
			3	436	75.60%	226,022,400	5,188.760	8.107
P-5	9	Parks, Recreation, Sports	1	40	55.00%	20,736,000	476.033	.743
			2	32	45.00%	16,588,800	380.826	.595
			3	72	12.50%	37,324,800	856.859	1.338
P-5	10	Buffer Zone	1					
			2	68	100.00%	35,251,200	809.256	1.264
			3	68	11.90%	35,251,200	809.256	1.264
		GRAND TOTAL:		576	100.00%	298,598,400	6,854.876	10.710

Plate No. 15

SCHEME NO. 120 - DENSITY STUDIES							THE CITY AS A SYSTEM - CENTRAL CITY
ZONE	NO. of Blks.	POP./ACRE.	EMPLOY./ACRE.	NO.CARS/ACRE @ 35%	NO.CARS/ACRE @50%	SQ.FT./ACRE	TOTAL BLDG. FL.AREA - SQ. FT.
		POP./BLOCK.	EMPLOY./BLOCK.	NO.CARS/BLOCK "	NO.CARS/BLOCK "	SQ.FT./BLOCK	
R-1	128	19.6	N.A.	6.5	6.5	7,850.0	12,168,000.0
		234.0	N.A.	156.0	156.0	93,500.0	
R-2	84	36.0	N.A.	10.3	10.3	7,200.0	7,232,400.0
		430.0	N.A.	123.0	123.0	86,100.0	
R-3A	12	171.0	N.A.	31.2	42.8	54,600.0	7,800,000.0
		2,025.0	N.A.	510.0	510.0	650.000.0	
R-3B	20	124.8	N.A.	31.2	31.2	40,800.0	29,700,000.0
		1,485.0	N.A.	371.0	371.0	486,000.0	
B-1	48	23.7	193.0	59.0	83.0	121,000.0	69,200,000.0
		136.8	2,300.0	1,900.0	2,700.0	1,440,000.0	
B-2	48	N.A.	140.0	78.0	112.0	70,000.0	40,000,000.0
		N.A.	1,660.0	930.0	1,330.0	830,000.0	
P-1	28	N.A.	107.0	38.0	54.0	21,600.0	7,200,000.0
		N.A.	1,280.0	450.0	640.0	257,000.0	
P-2	16	N.A.	84.0	64.0	84.0	67,000.0	12,800,000.0
		N.A.	1,000.0	760.0	1,000.0	800,000.0	
P-3	28	N.A.	96.0	57.0	80.0	80,500.0	38,400,000.0
		N.A.	1,140.0	674.0	960.0	960,000.0	
P-4	24	N.A.	28.0	248.0	248.0	87,000.0	24,883,200.0
		N.A.	333.0	2,950.0	2,950.0	1,035,000.0	
P-5	140	N.A.	1.8	3.0	4.4	---	1,000,000.0
		N.A.	21.4	36.0	52.0	---	
GRAND TOTAL:		120,000.Persons	480,000.0	314,680.0	430,000.0	---	250,383,600.0

Plate No. 16

S C H E M E 1 2 0 - R E S I D E N T I A L Z O N E A R E A S							
FUNC-TION	RESIDENTIAL		NO. of BLOCKS	%	LAND AREA (SQ. FT.)	LAND AREA (AC.)	LAND AREA (SQ. MI.)
R-1	Single Family Detached D.U. = 7,500	1	----	----	----	----	----
		2	128	100%	66,355,200	1,523.305	2.380
		3	128	52.4%	66,355,200	1,523.305	2.380
R-2	Single Family Attached D.U. = 10,300	1	----	----	----	----	----
		2	84	100%	43,545,600	999.669	1.561
		3	84	34.4%	43,545,600	999.669	1.561
R-3	Multi-Family Apartments D.U. = 18,000	1	12	37.5%	6,220,800	142.809	.223
		2	20	62.5%	10,368,000	238.016	.371
		3	32	13.2%	16,588,800	380.826	.595
GRAND TOTAL			244	100%	126,489,600	2,903.801	4.537

Plate No. 17

COMPREHENSIVE DESIGN CALCULATIONS FOR SCHEME NO. 240

RESIDENTIAL ZONE AREAS - SCHEME 240

R-1 Single Family Residential District

Type: Single Family Detached Residences

Total No. of Blocks: 48 (= 24,400,000 Sq. Ft. = 560 Acres)

Total No. of People: 12,000

Average Person/Family: 4

Total No. of D.U.: 12,000/4 = 3,000

Average Lot Size D.U.: $\frac{48 \times 518,400}{3,000}$ = 8,300 Sq. Ft. (included streets)

No. of D.U./Acre: 3,000/560 = 5.36/Acre

No. of People/Acre: 21.5 People/Acre

No. of D.U./Block: 3,000/48 = 62.5 D.U./Block

No. of People/Block: 250 People/Block

Average No. of Cars/D.U. = 1.5

Total No. of Cars: 1.5 x 3,000 = 4,500

No. of Cars/Block: 4,500/48 = 94

No. of Cars/Acre: 7.9 Cars/Acre

Average Building Size: 1,600 Sq. Ft./D.U.

Total Floor Sq. Ft.: 1,600 x 3,000 = 4,800,000 Sq. Ft.

Total Sq. Ft. of Parking Spaces: 4,500 x 600 = 2,700,000

Grand Total Floor Sq. Ft.: 4,800,000 + 2,700,000 = 7,500,000 (including parking garage)

Average Sq. Ft./Block: 7,500,000/48 = 156,000

F.A.R.: 156,000/518,400 = 0.3

R-2 Multiple Family Residential District

Type: Single Family Attached Residences

Total No. of Blocks: 144 (= 74,600,000 Sq. Ft. = 1,710 Acre)

Total No. of People: 72,000

Average Person/D.U.: 3.5

Total No. of D.U.: 72,000/3.5 = 20,600

Average Lot Size/D.U.: 144 x 518,400/20,600 = 3,700

No. of D.U./Acre: 20,600/1,710 = 11.7

No. of People/Acre: 46.8

No. of D.U./Block: 139

No. of People/Block: 556

Average No. of Cars/D.U.: 1.0

Total No. of Cars: 20,600

No. of Cars/Block: 20,600/144 = 139

No. of Cars/Acre: 11.7 Cars/Acre

Average Floor Sq. Ft./D.U.: 1,400 Sq. Ft./D.U.

Total Floor Sq. Ft.: 1,400 x 20,600 + 400 (20,600)
(including parking garage)
= 20,600 (1,800) = 37,000,000

Average Sq. Ft./Block: 37,000,000/144 = 257,000

F.A.R.: 257,000/518,400 = 0.5

R-3a <u>High Density Multiple Family Residential District</u>

Type: Multiple Family Apartments

(1) Walk Up Apartment

(2) Walk Up Apartment with High Rise Apartment

(3) High Rise Towers

Total No. of Blocks: 42 (= 21,800,000 Sq. Ft. = 500 Acres)

Total No. of People: 84,000

Average Person/D.U. = 3.0

Total No. of D.U.: 84,000/3 = 28,000

Average Lot Size/D.U.: 21,800,000/28,000 = 780

No. of D.U./Acre: 28,000/500 = 56

No. of People/Acre: 168

No. of D.U./Block: 666

No. of People/Block: 2000

Average No. of Cars/D.U.: 1.0

Total No. of Cars: 28,000

Total Sq. Ft. of Parking Space: 28,000 x 350 = 9,800,000

No. of Cars/Block: 28,000/42 = 666

No. of Cars/Acre: 56

Average Floor Sq. Ft./D.U.: 1000 (including circulation)

15% Efficiency-------500 Sq. Ft.

40% One Bedroom------750 Sq. Ft.

30% Two Bedroom-----1000 Sq. Ft.

15% Three Bedroom---1200 Sq. Ft.

Total Floor Sq. Ft.: 28,000,000 Sq. Ft.

Average Sq. Ft./Block: 28,000,000/42 = 666,000

Grand Total Floor Sq. Ft.: 28,000,000 + 9,800,000 = 37,800,000

F.A.R.: 37,800,000/21,800,000 = 1.73

R-3b <u>High Density Multiple Family Residential District</u>

Type: Apartment Complex within C.B.D. Area

Total No. of Blocks: 48 (= 24,400,000 Sq. Ft. = 570 Acres)

Total No. of People: 72,000

Average Person/D.U.: 2.5

Total No. of D.U.: 72,000/2.5 = 28,800

No. of D.U./Acre: 28,800/560 = 51

No. of People/Acre: 127

No. of D.U./Block: 600

No. of People/Block: 1,500

Average No. of Cars/D.U.: 0.75

Total No. of Cars: 21,600

No. of Cars/Block: 450

Total Sq. Ft. of Parking Space: 21,600 x 350 = 7,560,000

Average Floor Sq. Ft./D.U.: 970 (including circulation)

25% Efficiency-------500 Sq. Ft.

40% One Bedroom------650 Sq. Ft.

25% Two Bedroom------900 Sq. Ft.

10% Three Bedroom---1100 Sq. Ft.

Total Floor Sq. Ft.: 970 x 28,800 = 28,000,000

Grand Total Residential Floor Sq. Ft.: 28,000,000 + 7,560,000

= 35,560,000

B-1 Commercial and Business District - Scheme 240

Type: General Commerce and Business Area with mixed use of R-3A District

Example: Apartment Office Complex

Total No. of Blocks: 48 Blocks

Permissible Usage:

Type Employment	No. of Employees	Aver. Sq. Ft. Employee	Required Floor Area in Sq. Ft.
Retail Trade	58,000	600	35.0
Selected and Professional	20,000	400	8.0
Finance, Insurance, Real Estate	14,000	400	5.6
Contract Construction	18,000	300	5.4
Others (Misc.)	18,000	800	14.4
TOTAL:	128,000		68.4

Average Sq. Ft./Employee in C.B.D.: 68,400,000/128,000 =

530 Sq. Ft./Employee

Average No. of Employee/Block: 128,000/48 = 2,700 Empl./Block

Average Floor Sq. Ft./Block: 68,400,000/48 = 1,420,000

Note: 5% of maximum total floor area in C.B.D. could be located in R-3 and R-3B District. R-3B District is located within C.B.D. area with mixed use such as commercial, office and apt. complex.

Requirements of Residential Parking in C.B.D.

Average No. of People/Unit = 2.5

No. of People/Block: 72,000/48 = 1,500

No. of Units/Block: 1,500/2.5 = 600

No. of Cars/Unit: 0.75

No. of Cars/Block: 600 x 0.75 = 450

Total No. of Cars in C.B.D.: 450 x 48 = 21,600

Requirements of Commercial and Business Parking in C.B.D. District:

Assumption: 1.5 employees/car

25% of people use auto and 75% of people use transit

	No. of Employees	No. of Employees Car	No. of Visitors Car	Aver. Sq. Ft./ car	Floor Area	No. of Cars
Retail Trade	58,000	9,700	106,300	300	35,000,000	116,000,000
Selected & Professional	20,000	3,300	14,400	450	8,000,000	17,700,000
Finance, Insurance	14,000	2,340	10,966	500	5,600,000	11,200,000
Contract Construction	18,000	2,650	10,850	400	5,400,000	13,500,000
Others	18,000	2,500	15,000	800	14,000,000	17,500,000
TOTAL:	128,000	20,490	147,516		68,400,000	168,000,000

Total No. of Cars: 20,490 + 147,516 = 168,000

Average No. of Cars/Block: 148,000/48 = 3,500

Grand Total No. of Cars Required in C.B.D.:

168,000 + 21,600 = 189,600

Average No. of Cars/Block = 189,600/48 = 4,000

Proposed Parking Requirement in C.B.D.: (Except the Residential

Parking in C.B.D.

30% of total parking requirement is distributed in peripheral

boundary parking garage: $189{,}600 \times \frac{30}{100} = 56{,}600$ Cars

Final No. of Cars in C.B.D.: 132,500

Average No. of Cars in C.B.D./Block: 132,500/48 = 2,760

Sq. Ft. of Parking Space/Block: 2,760 x 350 = 970,000

Percent of Parking Coverage: $\frac{970,000 \times 100}{518,400} = 187\%$

Maximum Building Coverage: 50%

$518,400 \times \frac{50}{100} =$ 260,000 Sq. Ft. Land Coverage/Block

Average Building in Stories in C.B.D.:

68,400,000 + 21,700,000 = 90,100,000

90,100,000/260,000 x 48 = 7.2

Grand Total Sq. Ft. (Including Residential, Commercial & Parking):

$\frac{46,000,000}{\text{Parking}} + \frac{25,200,000}{\text{Residential}} + \frac{68,400,000}{\text{Commercial}} =$ 139,600,000 Sq. Ft.

Total Sq. Ft./Block: (Including Parking, Residential and Commercial) 139,600,000/56 = 2,500,000

F.A.R.: 2,500,000/518,400 = 4.8

B-2 <u>Light Manufacturing and Wholesale District</u>

Type: All activities concerned with the production or fabrication of goods, and wholesale district with or without stock, such as warehouse storage.

Total No. of Blocks: 56 Blocks

Total Employees: 108,000

Type Employment	No. of Employees	Aver. Sq. Ft. Employee	Floor Sq. Ft.
Wholesale Trade	18,000	1,000	18,000,000
Manufacture	90,000	500	45,000,000
TOTAL:	108,000		63,000,000

Average No. of Employees/Block: 108,000/56 = 1,940

Average Sq. Ft./Block: 63,000,000/56 = 1,120,000

Requirements of Parking Space:

	No. of Employees Car	No. of Visitors Car	Aver. Sq. Ft./ Car	Floor Area	No. of Cars
Wholesale Trade	3,000	9,000	1,500	18,000,000	12,000
Manufacture	15,000	30,000	1,000	45,000,000	45,000
TOTAL:	18,000	39,000		63,000,000	57,000

No. of Parking/Block: 57,000/56 = 1,020

Total Sq. Ft. of Parking Space: 57,000 x 350 = 20,000,000

Floor Sq. Ft. of Parking/Block: 1,020 x 350 = 356,000

% of Parking Coverage: $356 \times \frac{100}{516} = 69\%$

Recommended Parking Requirements:

30% of Parking Spaces in B-2 District could be distributed in peripheral boundary parking garage:

$57{,}000 \times \frac{30}{100} = 17{,}100$

Final Average No. of Cars/Block: 700

% of Parking Coverage: 48%

Total Sq. Ft. of Parking Space: 14,000,000

Average Floor Sq. Ft./Block: 63,000,000/56 = 1,120,000
(without parking space)

Average Floor Sq. Ft./Block: (63,000,000 + 14,000,000)/56
(with parking space)

= 77,000,000/56

= 1,370,000

F.A.R.: 1,370/518,400 = 2.66
(including parking)

GENERAL PUBLIC SERVICES - SCHEME 240

P-1 <u>Government Administration - Scheme 240</u>:

Type: City Hall, Post Office, Federal Office, State Office, Municipal Office

Total No. of Blocks: 16 Blocks

Total No. of Employees: 38,000

Average No. of Employees/Block: 38,000/16 = 2,400

Average Sq. Ft./Employee: 300

Required Floor Area: 38,000 x 300 = 11,400,000

Floor Area/Block: 7,600,000/16 = 475,000

Required Average Sq. Ft./Car: 400

Total No. of Cars: 11,400,000/400 = 28,500

No. of Employee Cars: 6,300

No. of Customer Cars: 22,200

No. of Cars/Block: 28,500/16 = 1,780

Proposed Parking Requirements: 30% of total parking space could be distributed in periphery boundary parking garage:

$$28{,}500 \times \frac{30}{100} = 8{,}550$$

Proposed total of No. of Cars: 28,500 - 8,550 = 19,950

Average No. of Parking/Block: 19,950/16 = 1,250

Total Floor Area Sq. Ft. including Parking Garage:

$$11{,}400{,}000 + \frac{19{,}950 \times 350}{465} = 11{,}400{,}000 + 7{,}000{,}000/\text{parking}$$

$$= 18{,}400{,}000$$

$$\text{F.A.R.: } \frac{18{,}400{,}000}{16 \times 518{,}400} = 2.22$$

P-2 Cultural and Other Non-Profit Institutions

Type: Civic Auditorium, Theatre, Library, Museum of Art, Museum of Science, Health Service, and other non-profit organizations

Total No. of Blocks: 16 Blocks

Total No. of Employees: 12,000

Average No. of Employee/Block: 12,000/16 = 750

Average Sq. Ft./Employee: 800

Required Floor Area: 800 x 12,000 = 9,600,000

Floor Area/Block: 9,600,000/16 = 600,000

Required Average Sq. Ft./Car: 1,000

Total No. of Cars: 9,600,000/1,000 = 9,600

Proposed Parking Requirements: 30% total parking space could be distributed in periphery boundary parking garage

$9,600 \times \frac{30}{100} = 2,880$

Proposed total No. of Car: 9,600 - 2,880 = 6,720

Average No. of Parking/Block: 6,720/16 = 420

Total Floor Area Sq. Ft. including Parking Garage

9,600,000 + 2,350,000 11,950,000

F.A.R.: $\frac{11,950,000}{16 \times 518,400} = 1.44$

P-3 Educational Institutions

Type: Elementary School, Junior High School, Senior High School, Colleges

Total No. of Blocks: 36 Blocks

Total No. of Employees: 36,000

Average No. of Employee/Block: 36,000/36 = 1,000

Average Sq. Ft. of Floor Area/Employees: 1,200

Total Requirement Floor Area: 1,200 x 36,000 = 43,000,000

Note: 30% of above total requirements of floor area is located within Residential District.

$$43{,}000{,}000 \times \frac{30}{100} = 12{,}900{,}000$$

Required Average Sq. Ft./Car: 1200

Total No. of Cars: 43,000,000/1200 = 36,000

Proposed Parking Requirements: 30% of total parking space could be distributed in periphery boundary parking garage

$$36{,}000 \times \frac{30}{100} = 10{,}800$$

Proposed total No. of Cars: 36,000 - 10,800 = 25,200

Average No. of Parking/Block: 25,200/36 = 700

Total Floor Area in Sq. Ft. including Parking Garage:

$$\frac{8{,}800{,}000}{25{,}200 \times 350} + 43{,}000{,}000 = 51{,}800{,}000$$

$$\text{F.A.R.:} \quad \frac{51{,}800{,}000}{36 \times 518{,}400} = 2.8$$

P-4 <u>Communications and Utilities</u>

Type: Parking Facility, Subway Stations, Bus Terminals, Oil Station, Utilities

Total No. of Blocks: 24 Blocks--Parking Garage with 3 levels plus 17% of above land area is distributed in random all over the center city

Total No. of Employees: 10,000

Average No. of Employee/Block: 10,000/24 = 416

Total No. of Cars: $\frac{3 \times 24 \times 518{,}400}{350} = 107{,}000$

Distribution: C.B.D.------56,500

B-2 -------17,100

P-1 ---------8,550

P-2 --------3,880

P-3 --------12,900

Total 98,930

plus others (miscellaneous) 8,070

Total 107,000

P-5 Recreation, Parks, and Open Space

Type: Public Park, Zoo, Open Space

Total No. of Blocks: 156 Blocks

Total No. of Employees: 4,000

Average No. of Employees/Block: 4,000/156 = 25.6

Requirements of Average Sq. Ft./Car: 10,000

Total No. of Cars: 156 x 518,400/10,000 = 8,100

No. of Cars/Block: 8,100/156 = 52

SCHEME NO. 240 - DENSITY STUDIES — THE CITY AS A SYSTEM - CENTRAL CITY

ZONE	NO. of Blks.	POP./ACRE. / POP./BLOCK.	EMPLOY./ACRE / EMPLOY./BLOCK	NO.CARS/ACRE / NO.CARS/BLOCK.	SQ.FT./ACRE+Pk. / SQ.FT./BLOCK+Pk.	SQ.FT./ACRE / SQ.FT./BLOCK.	TOTAL SQ.FT. FLOOR AREA WITH PARKING INCLUDED.
R-1	48	21.5	N.A.	7.9	---	---	7,500,000.
		250.0	N.A.	94.0	156,000.	4,800,000.	
R-2	144	46.8	N.A.	11.7	---	---	37,000,000.
		556.0	N.A.	139.0	257,000.	---	
R-3A	42	168.0	N.A.	56.0	---	---	37,800,000.
		2,000.0	N.A.	666.0	666,000.	28,000,000.	
R-3B	48	127.0	N.A.	44.0	---	---	35,560,000.
		1,500.0	N.A.	450.0	---	---	
B-1	48	N.A.	---	---	---	---	139,600,000.
		N.A.	2,700.0	2,450.0	2,500,000.	---	
B-2	56	N.A.	---	---	---	---	1,370,000.
		N.A.	1,940.0	700.0	1,370,000.	---	
P-1	16	N.A.	---	---	---	---	18,400,000.
		N.A.	2,400.0	1,250.0	1,150,000.	11,400,000.	
P-2	16	N.A.	---	---	---	---	11,950,000.
		N.A.	750.0	420.0	747,000.	---	
P-3	36	N.A.	---	---	---	---	51,800,000.
		N.A.	1,000.0	700.0	1,440,000.	---	
P-4	24	N.A.	---	---	---	---	35,000,000.
		N.A.	416.0	4,458.0	1,460,000.	---	
P-5	156	N.A.	---	---	---	---	1,000,000.
		N.A.	25.5	52.0	---	---	
Grand Total	576	---	---	---	N.A.	N.A.	372,980,000.

Plate No. 18

GENERAL ANALYSIS OF CONSTRUCTION CAPABILITY

General Analysis of Construction Capability:

This study is a general analysis of the capability of the construction industry to handle the volumetric requirements of the proposed central city for both Scheme no. 120 and 240. This information gives a clear feedback as to the potential growth of a new city under rapid growth criteria. The material upon which this analysis is based upon is a recent survey which includes all known reliable sources.

1. Data on Floor Space Capability Per Type:

From pp. 20 - 21, this material is the latest figures available for the year 1963.

A. Total Bldg. (excluding public works and utilities)

a. Total: 2,711,100,000 Sq. Ft./nation

b. Aver.: 56,479,100 Sq. Ft./state

B. Total Non-Residential

a. Total: 957,800,000 Sq. Ft./nation

b. Aver.: 19,958,300 Sq. Ft./state

C. Total Commercial & Industrial

a. Total: 533,850,000 Sq. Ft./nation

b. Aver.: 11,125,000 Sq. Ft./state

D. Commercial

a. Total: 346,970,000 Sq. Ft./nation

b. Aver.: 7,229,100 Sq. Ft./state

E. Industrial

a. Total: 186,880,000 Sq. Ft./nation

b. Aver.: 3,895,800 Sq. Ft./state

Robert E. Lipsey and Doris Preston, Source Book of Statistics Relating to Construction (National Bureau of Economic Research; New York) 1966, pp. 18, 20 - 21.

F. Public & Institutional

a. Total: 391,590,000 Sq. Ft./nation

b. Average: 8,166,600 Sq. Ft./state

G. Public

a. Total: 305,440,000 Sq. Ft./nation

b. Average: 6,354,100 Sq. Ft./state

H. Total Residential

a. Total: 1,753,400,000 Sq. Ft./nation

b. Average: 36,520,800 Sq. Ft./state

I. Number of New Dwelling Units

a. Total: 1,460,800,000 Sq. Ft./nation

b. Average: 30,416,600 Sq. Ft./state

2. <u>Construction Cost (Sq. Ft.) Per Type:</u>

A. Total Bldg. Cost/Sq. Ft. Average

$$\frac{\$299,520,800 \text{ State}}{56,479,100 \text{ Sq.Ft.}} = \$5.3032/\text{Sq. Ft.}$$

B. Total Bldg. Cost/Sq. Ft. for Commercial & Industrial

$$\frac{\$139,958,300 \text{ State}}{11,125,000 \text{ Sq.Ft.}} = \$12.5804/\text{Sq. Ft.}$$

C. Total Bldg. Cost/Sq. Ft. for Commercial

$$\frac{\$92,583,300 \text{ State}}{7,229,100 \text{ Sq.Ft.}} = \$12.8070/\text{Sq. Ft.}$$

D. Total Bldg. Cost/Sq. Ft. for Industrial

$$\frac{\$47,354,100 \text{ State}}{3,895,000 \text{ Sq.Ft.}} = \$12.1576/\text{Sq. Ft.}$$

E. Total Bldg. Cost/Sq. Ft. for Public & Institutional

$$\frac{\$149,270,800 \text{ State}}{8,166,600 \text{ Sq.Ft.}} = \$18.2782/\text{Sq. Ft.}$$

F. Total Bldg. Cost/Sq. Ft. for Public

$$\frac{\$120,041,600 \text{ State}}{6,354,100 \text{ Sq.Ft.}} = \$18.8919/\text{Sq. Ft.}$$

G. Average Size of Dwelling Unit Constructed in 1963

$$\frac{36,520,800 \text{ Sq. Ft./state}}{30,416 \text{ D.U./state}} = 1200.7101 \text{ Sq. Ft./D.U.}$$

Approximation of Construction Cost and Volumetric Capability/State

For Scheme No. 120 and 240

1. Total Cost of City Project:

These figures approximate very roughly the construction cost of the total volumetric requirements of both city schemes:

Scheme no. 120:

$$329,033,000 \text{ S.F.} \times \frac{\$5.30}{\text{S.F.}} = \$1,740,000,000.$$

Scheme no. 240:

$$387,420,000 \text{ S.F.} \times \frac{\$5.30}{\text{S.F.}} = \$2,050,000,000.$$

2. Residential Construction Capability:

These figures are based on a twenty-five year projected growth period of equal increments for the total central city of both schemes:

Scheme no. 120 Construction Capability:

a. Total = 27,000,400 Sq. Ft.

b. Per Year = 1,080,000 Sq. Ft./Yr.

1,080,000/36,520,800 = 3.0% of annual capacity

Scheme no. 240 Construction Capability:

a. Total = 72,468,000 Sq. Ft.

b. Per Year = 2,900,000 Sq. Ft./Yr.

2,900,000/36,520,800 = 8.0% of annual capacity

3. Commercial Construction Capability and Cost:

These figures are based on a twenty-five year projected growth period of equal increments for the total central city of both schemes:

Zone B-1 Commercial Construction Capability:

Scheme no. 120:

1. 2,800,000 Sq. Ft./yr. = 38.0%

Scheme no. 240:

2. 4,800,000 Sq. Ft./yr. = 69.0%

Zone B-2 Light Manufacturing Construction Capability:

Scheme No. 120:

1. 1,600,000 Sq. Ft./yr. = 42.0%

Scheme no. 240:

2. 3,080,000 Sq. Ft./yr. = 80%

Zone B-1 Commercial Cost:

These figures reflect the cost based on the annual budget per state--

Scheme no. 120:

$35.8M/$92.583M = 39.0% % of Annual Budget

Scheme no. 240:

$57.5M/$92.583M = 62.0% % of Annual Budget

Zone B-2 Light Manufacturing Cost:

Scheme no. 120:

$20.0M/$47.3M = 42.5% % of Annual Budget

Scheme no. 240:

$37.0M/$47.3M = 78.0% % of Annual Budget

4. Public Facilities Construction Capability and Cost:

These figures are based on a twenty-five year projected growth period of equal increments for the total central city of both schemes:

Zone P1-5 Construction Capability:

Scheme no. 120:

a. Total = 84,283,200 Sq. Ft.

b. Per Year = 3,888,000 Sq. Ft./Yr.

= 47% of annual capacity

Scheme no. 240:

a. Total = 118,232,000 Sq. Ft.

b. Per Year = 4,750,000 Sq. Ft.

= 58% of annual capacity

Zone P 1-5 Construction Cost:

Scheme no. 120:

$70.0M/$149.2M = 47% of annual budget

Scheme no. 240:

$86.5M/$149.2M = 58% of annual budget

GENERAL CONCLUSIONS FOR THE CITY AS A SYSTEM STUDY

GENERAL CONCLUSIONS

The following discussion clarifies the basic conclusions, evaluations, and final design criteria of the planar city systems model.

In Scheme no. 120 we provided more single family residential living units in the central city according to available percentages of existing cities. In the core area, we have implemented a population density less than that of the core fringe, and consequently this resulted in marked differences in daytime and nighttime activity intensiveness. During the daytime, we have a high employee density in the core and at nighttime the city core will be vacant because of a small resident population density.

Realizing this conflict in Scheme no. 120, we provided in the subsequent Scheme no.240, a higher population density in the core to supplement the existing high employee density. This provides for several immediate advantages:

1.) a day and night activity level of proportionate intensity,

2.) a reduction of parking facilities for resident employees who commute via subway or surface bus lines, and

3.) a possible variety of architectural solutions to combination office-apartment structures, providing for immediate accessibility from living to working quarters. This condition is assumed to be valid within reasonable percentages of density and social constraints of age and professional requirements.

In Scheme no. 120, the zoning was planned on general assumptions without regarding the transportation network which was supplanted upon it or the activity areas which were juxtaposed to the main circulation lines. Realizing the obvious weaknesses between the zoning areas and the transportation net system, we provided for immediate and direct relationships between these two inter-related functions in the second

Scheme no. 240. In the use of direct overlays, we were able to accurately judge correct positions of local and express subway lines and vehicular lines for bus and truck services to the central civic core or C.B.D.

In the parking study, our first scheme no. 120 provided 50% of the people commuting to employment in the central city core to use their own cars as a means of transportation; but we soon realized that this represented a very high percentage of auto usage being reflected in high parking density requirements. We then reduced the percentage in a second alternative study to 35% auto usage, and a higher value for the more efficient rapid transit system for suburban commuters.

In Scheme no. 240, we emphasized a high percentage of population density in the downtown core, and also reduced the floor area requirements per dwelling unit for high rise apartments; consequently we also provided for a more frequent usage of the mass transit system. In addition, we also found that vehicular circulation for secondary traffic was increased by a one-way street system along the cain central transverse and longitudinal axes--this reduced the number of conflict points and permitted increased velocity along the full width of the roadway. The main commercial, governmental, and other manufacturing zone areas are generally included within this one-way traffic axis to provide for quick accessibility and inter-zone circulation convenience. In this solution, the primary residential areas are located at the four corners of the center city matrix model. At this point, the vehicular circulation system returned to a two-way access road for general convenience and economy.

In Scheme no. 240, the major circulation spline is tri-part and flanks the perimeter of the central city core. This is an improvement over Scheme no. 120 where the circulation system of a major artery splits the core as appropriately shown by the cartoon on plate no. 19

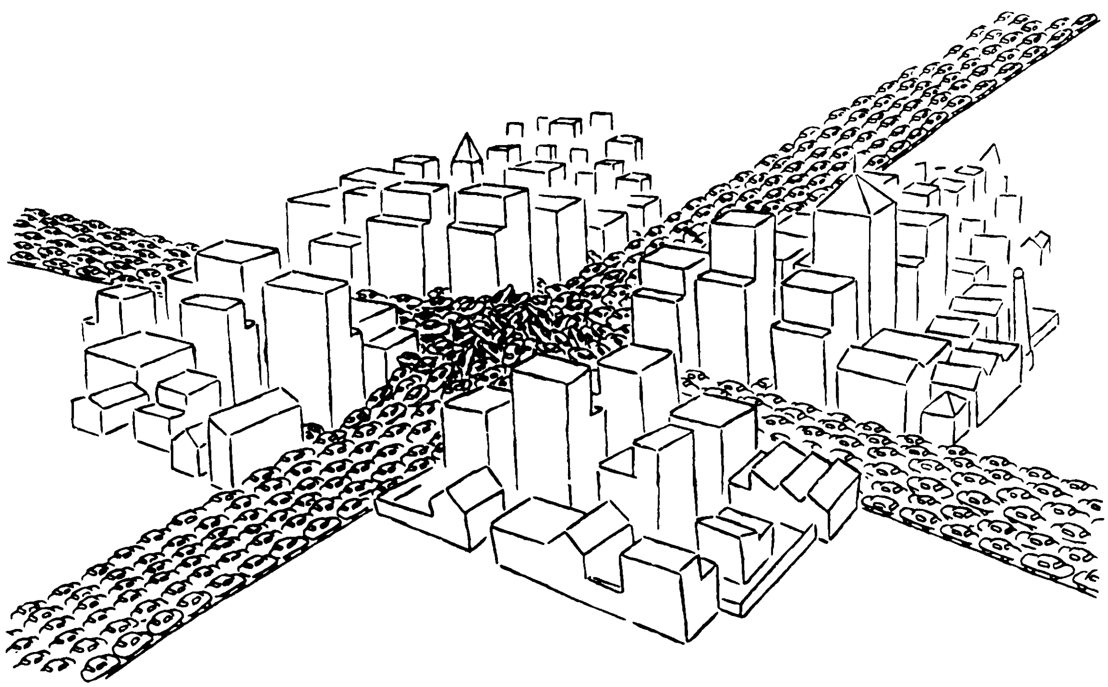


Plate No. 19 CENTRAL CITY CONGESTION

What must happen if one moves automobiles from millions of outlying points to one central point without planning.

By: Victor Gruen
The Heart of Our Cities
Simon & Schuster - New York
Pg. 100

This humorous portrait depicts the current problem very succinctly.

Also of relative importance is the decision to vary the city block size in Scheme no. 240 according to the intensity of land usage. The three basic alternatives provided were the following:

a) one block = 720' x 720'

b) two block = 720' x 1440'

c) four block = 1440' x 1440'
(mega-block)

In prior research and evaluation of current city block sizes and its immediate circulation system, we found a high orientation to vehicular traffic which accounted for undue waste of available land and inefficient circulation patterns. By having the above variation of large block sizes, almost twice that of present city blocks in land area, and developing a multi-level circulation system for differentiating major traffic types, we provided for a 10% savings in available land area and also gave a valid basis for a more flexible and inter-related system of planning and building. For example, we chose as the final study area of the urban building system a mega-block in the central business district to show the advantages of developing a contiguous urban environment which is oriented for pedestrian traffic by an uninterrupted pedestrian walkway. The vehicular circulation system moves over and under this continuous pedestrian level; plate no. 20 shows why existing city circulations systems have failed to surmount the obvious conflicts inherent in a single ground level solution for high intensity urban districts.

In the residential area, we also provided a mega-block solution for the principle reason that the site plan can be as flexible as the requirements and options the planners choose--they could have a system of internal local streets, one or two way, as much as the project density requires.

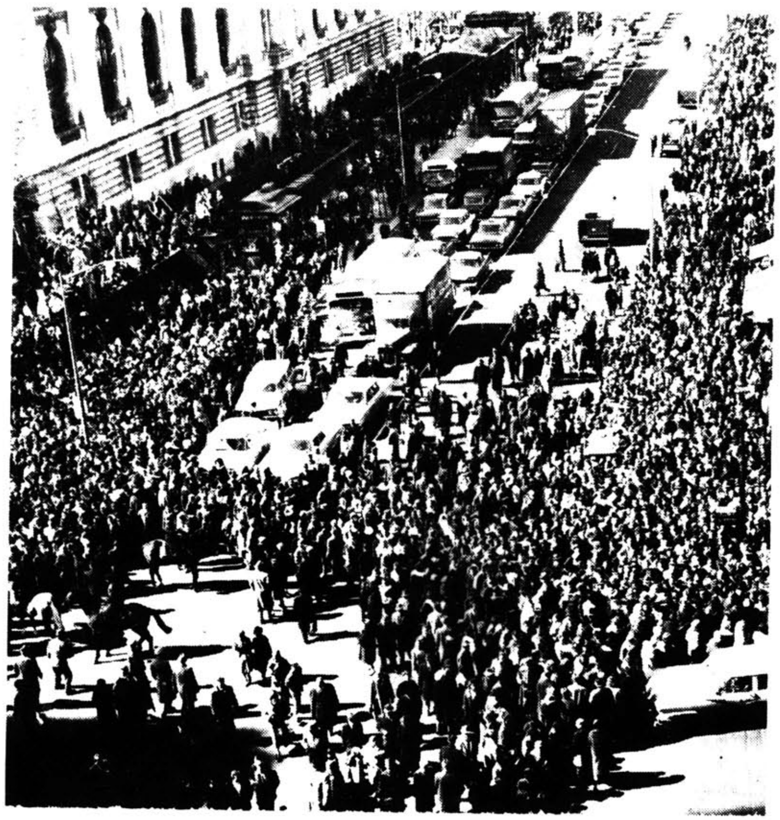


Plate No. 20 PEDESTRIAN-VEHICULAR CONFLICT

By: Victor Gruen
The Heart of Our Cities
Simon & Schuster - New York
Pg. 88

The final city solution was developed for the restructured Scheme no. 240, which included an integrated truch route for general service supplies, as well as the required loading areas. The truck service routes were placed in the center of the mega-blocks for efficient and economical dispersal of goods; and from the reserved loading areas, secondary pick-up trucks can quickly distribute the goods to vertical service elevators or adjacent storage facilities.

We found that in Scheme no. 240, we could predict very precisely the exact location of subway stations and bus stops because of the strong relationships between the zoning and transportation net systems. By having all of the visual charts superimposed upon the zoning map for population density, employee density, parking density, and volumetric density, we were able to see the total picture required of the circulation system--giving us the effective frequency of subway stations and the maximum walking distances to the bus stop and subway stations. As a design approach, we were then able to validate our decisions both accurately and quantitatively.

It is obvious that this process of correction and adjustment is reiterative and that given the proper optimization criteria for the problem, a final solution may be reached. Once the overall structure of the city is developed, quantitative information can be further manipulated to help discern the following pertinent design development:

1) Predicting the growth and staging of the city, both for key commercial elements and residential units.

2) Predicting from the growth requirements and the consequent volumetric areas, the cost of the annual budget to fund such a project and the construction capability of the regions resources. From this study, total staging over an adequate period of time can be properly assessed.

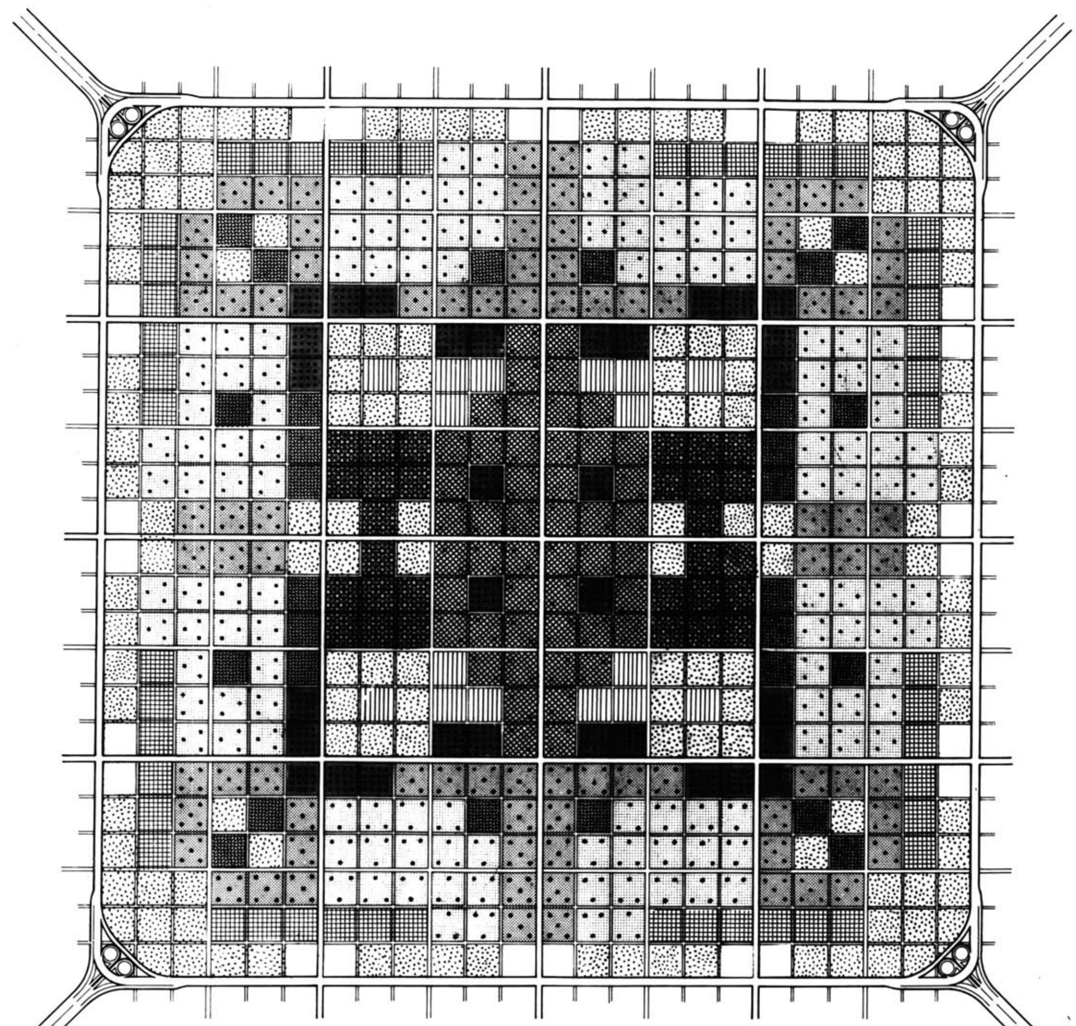
Our major recommendation regarding the problem of the network of the 'city as a system' is the increased application of rapid transit systems to the outlying suburban communities to reduce the tremendous congestions inherent in a central city concept; and to provide periphery parking lots at correct distances to the central city core to provide optimization of correct land usage and commuter convenience for properly designed residential densities in outlying regional districts.

Our second major recommendation falls within the design methodology of solving and establishing a total city structure problem. The first aspect is to clearly define all of the critical design variables and their inter-active relationships; and secondly, to implement this process with current computer technology for data manipulation and graphic output for quick, efficient, and responsible reference points to provide practical alternatives to an optimum solution; or an optimum critical sequential staging of a continuing problem or process.

DRAWINGS OF THE CITY AS A SYSTEM

THE CITY AS A SYSTEM

Scheme No. 120



RESIDENT POPULATION DENSITY

720'
0 1440'

• : 80 PERSONS

ZONING :

- R-1 SINGLE FAMILY RESIDENTIAL DETACHED
- R-2 SINGLE FAMILY RESIDENTIAL ATTACHED
- R-3 MULTI-FAMILY APARTMENTS
- B-1 BUSINESS & COMMERCIAL
- B-2 LIGHT MANUFACTURING
- P-1 ADMINISTRATION
- P-2 CULTURAL - ENTERTAINMENT
- P-3 EDUCATIONAL
- P-4 PERIPHERY PARKING
- P-5 PARKS - BUFFER ZONE

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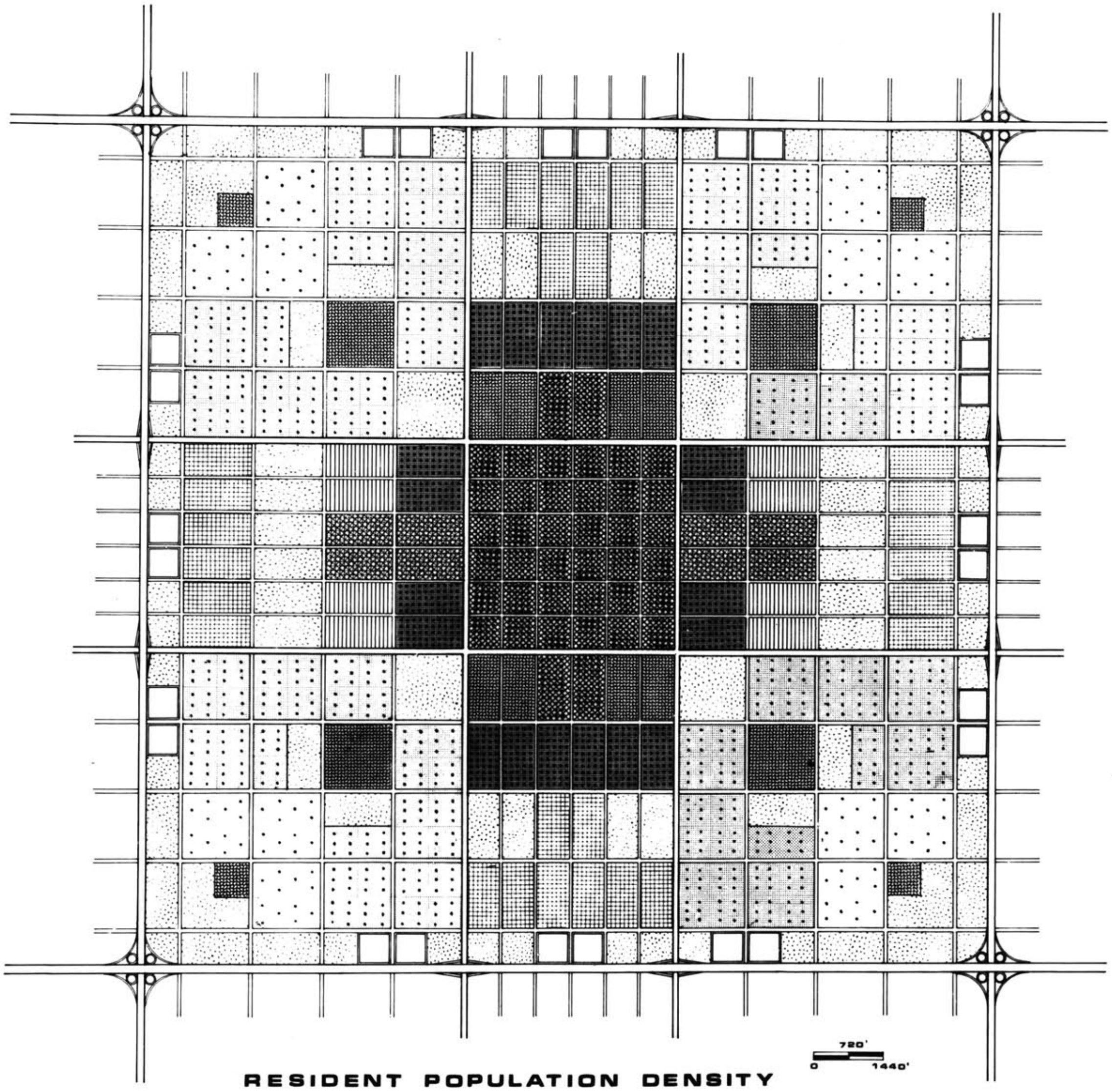
THE CITY AS A SYSTEM

<u>Scheme No. 240</u>



RESIDENT POPULATION DENSITY

• : 80 PERSONS

ZONING:

- **R-1** SINGLE FAMILY RESIDENTIAL DETACHED
- **R-2** SINGLE FAMILY RESIDENTIAL ATTACHED
- **R-3** MULTI-FAMILY APARTMENTS
- **B-1** BUSINESS & COMMERCIAL
- **B-2** LIGHT MANUFACTURING & WHOLESALE
- **P-1** ADMINISTRATION
- **P-2** CULTURAL - ENTERTAINMENT
- **P-3** EDUCATIONAL
- **P-4** PERIPHERY PARKING
- **P-5** PARKS - BUFFER ZONE

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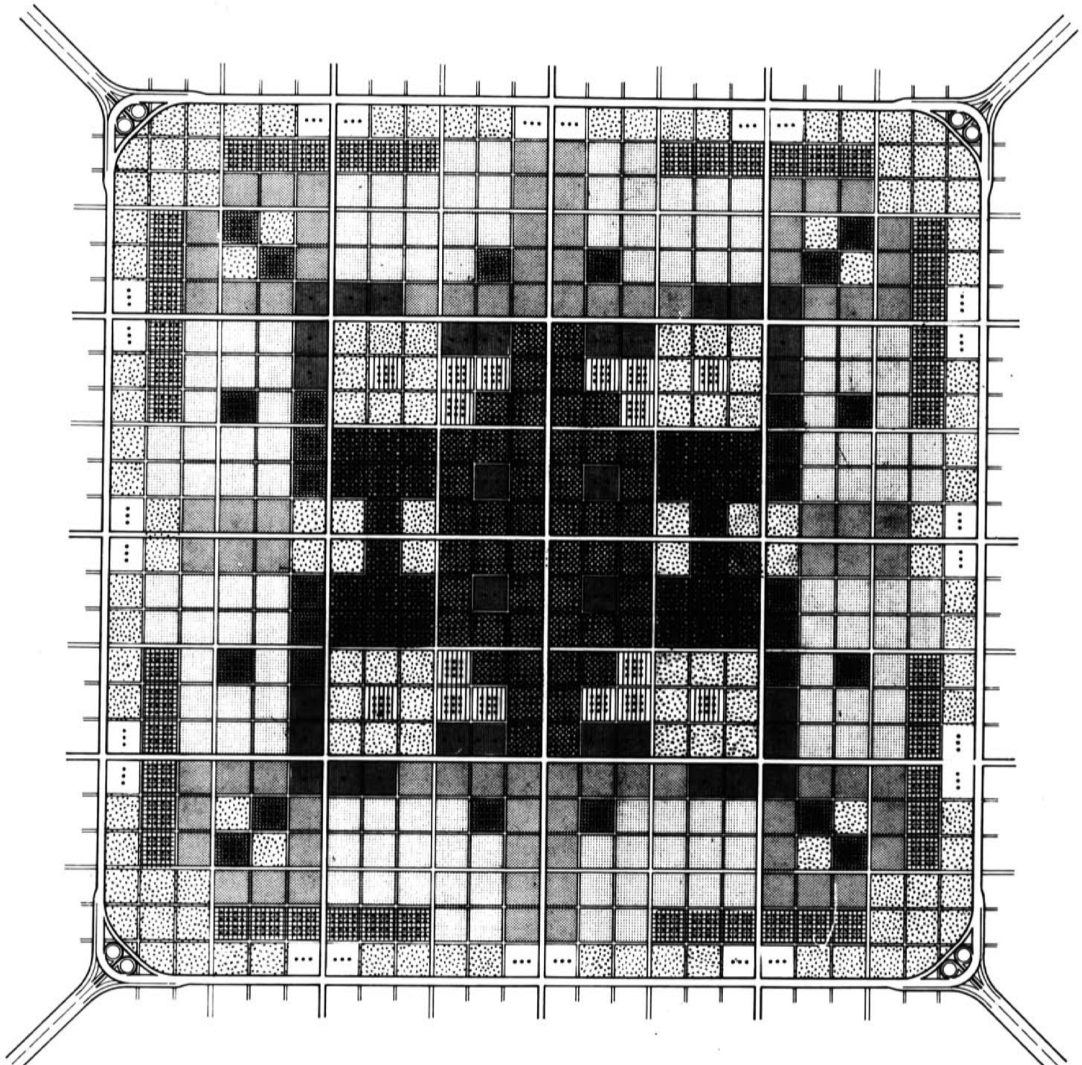
Scheme No. 120



EMPLOYEE POPULATION DENSITY

720' 0 1440'

• : 100 PERSONS

ZONING :

- R-1 SINGLE FAMILY RESIDENTIAL DETACHED
- R-2 SINGLE FAMILY RESIDENTIAL ATTACHED
- R-3 MULTI-FAMILY APARTMENTS
- B-1 BUSINESS & COMMERCIAL
- B-2 LIGHT MANUFACTURING
- P-1 ADMINISTRATION
- P-2 CULTURAL - ENTERTAINMENT
- P-3 EDUCATIONAL
- P-4 PERIPHERY PARKING
- P-5 PARKS - BUFFER ZONE

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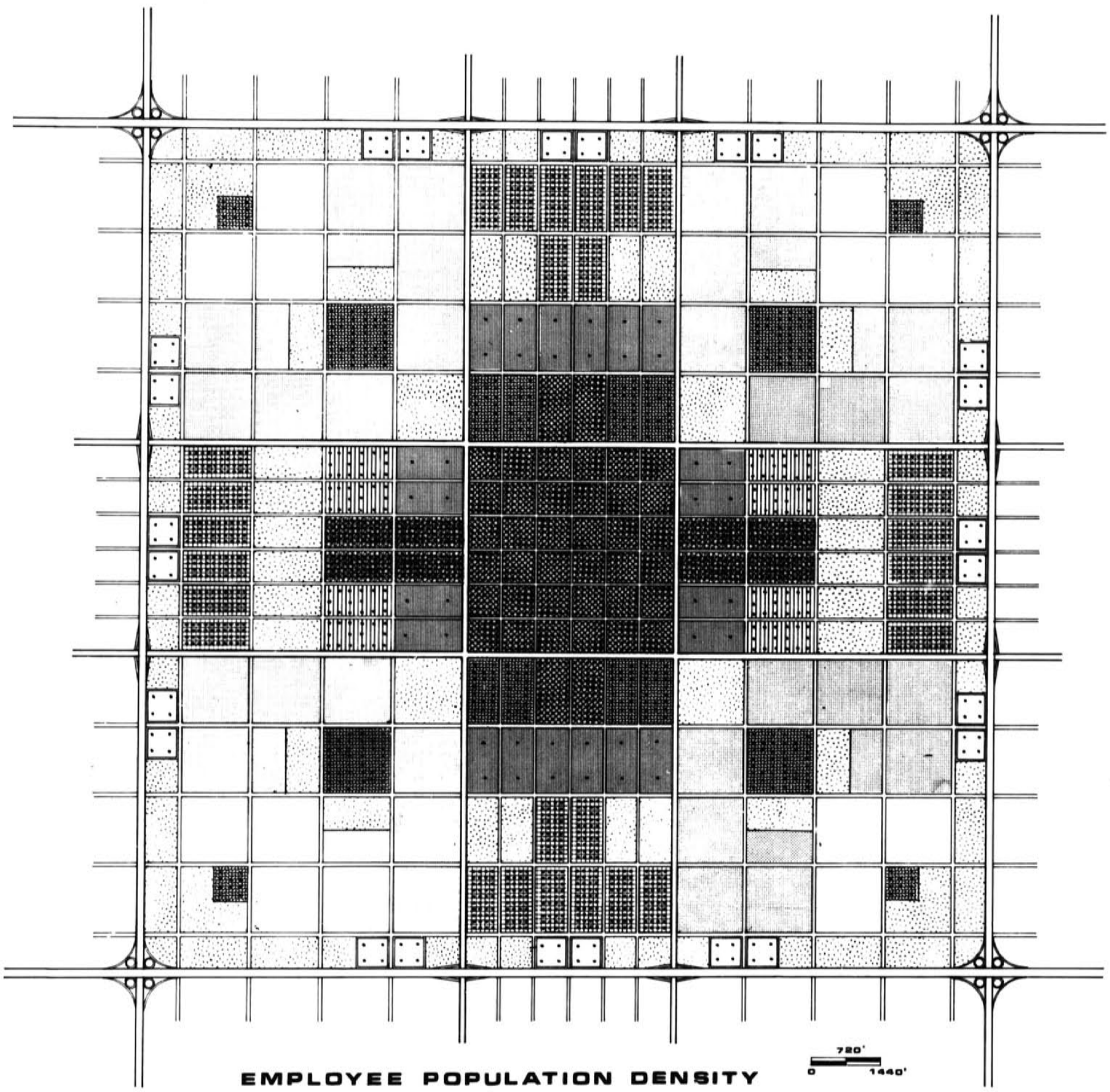
Scheme No. 240



EMPLOYEE POPULATION DENSITY

• : 100 PERSONS

ZONING:

- **R-1** SINGLE FAMILY RESIDENTIAL DETACHED
- **R-2** SINGLE FAMILY RESIDENTIAL ATTACHED
- **R-3** MULTI-FAMILY APARTMENTS
- **B-1** BUSINESS & COMMERCIAL
- **B-2** LIGHT MANUFACTURING & WHOLESALE
- **P-1** ADMINISTRATION
- **P-2** CULTURAL - ENTERTAINMENT
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- **P-5** PARKS - BUFFER ZONE

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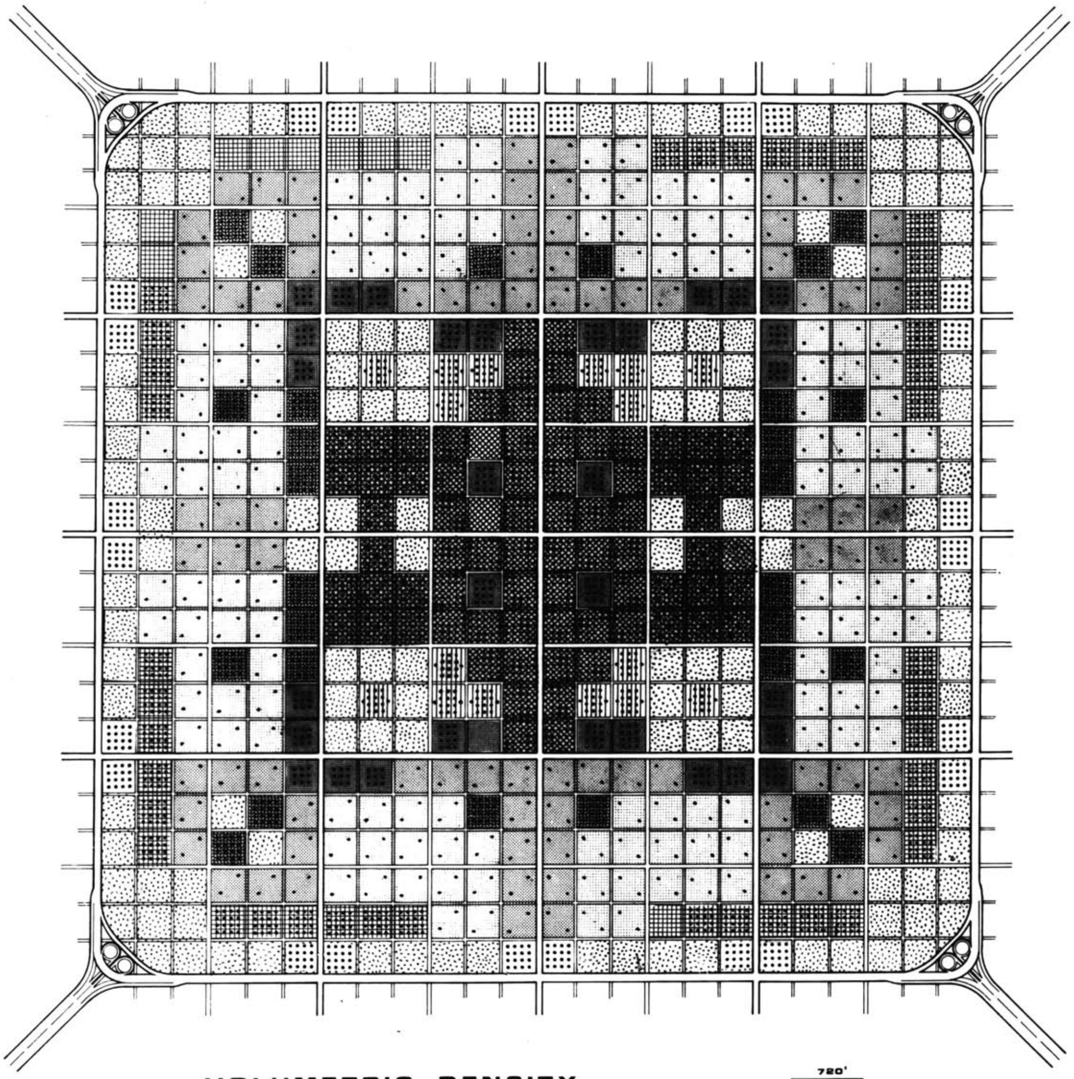
Scheme No. 120



VOLUMETRIC DENSITY

• : 60,000 SQ. FT.

ZONING:

R-1 SINGLE FAMILY RESIDENTIAL DETACHED

R-2 SINGLE FAMILY RESIDENTIAL ATTACHED

R-3 MULTI-FAMILY APARTMENTS

B-1 BUSINESS & COMMERCIAL

B-2 LIGHT MANUFACTURING

P-1 ADMINISTRATION

P-2 CULTURAL - ENTERTAINMENT

P-3 EDUCATIONAL

P-4 PERIPHERY PARKING

P-5 PARKS - BUFFER ZONE

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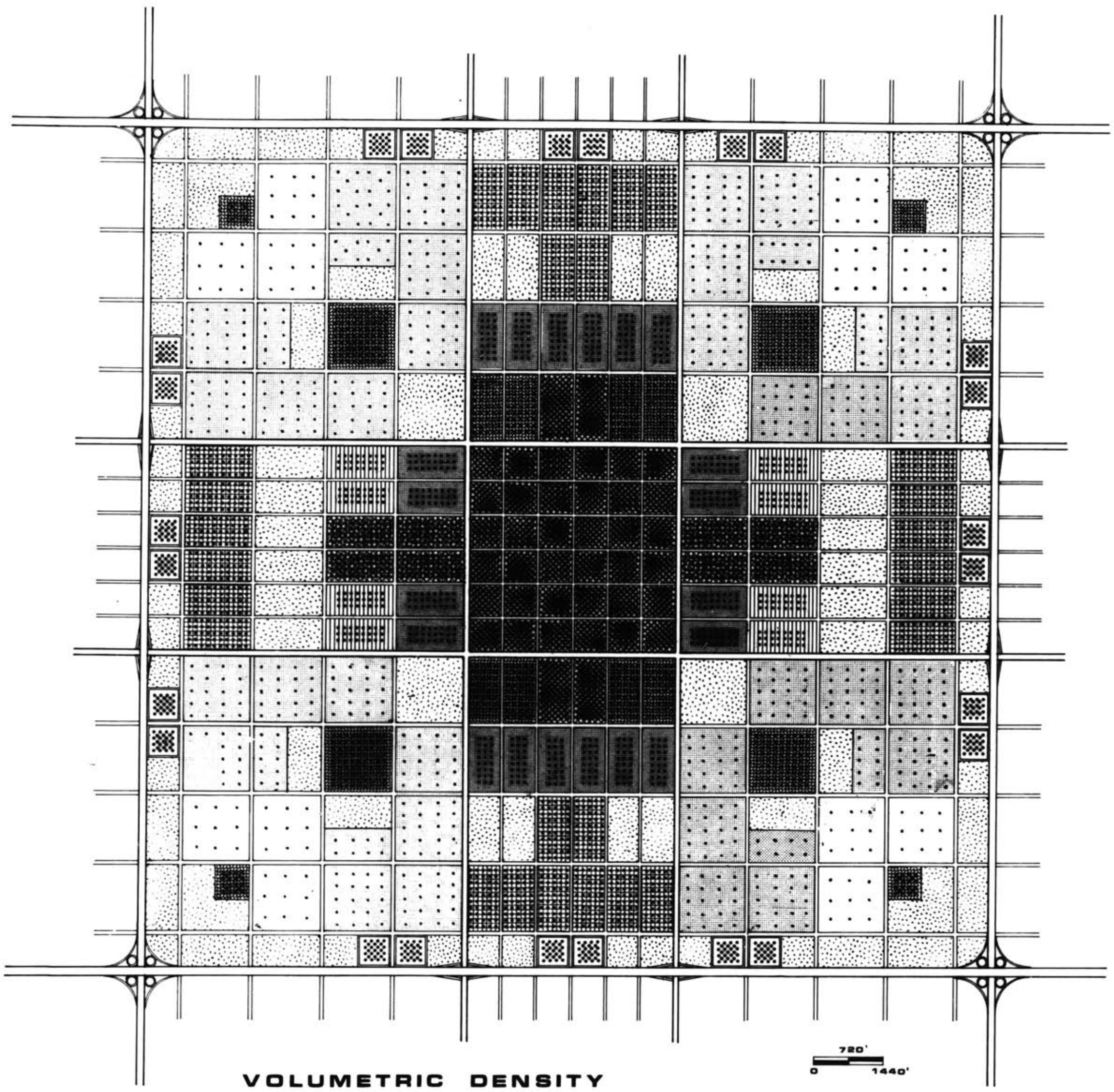
Scheme No. 240



VOLUMETRIC DENSITY

• : 60,000 SQ. FT.

ZONING:

- R-1 SINGLE FAMILY RESIDENTIAL DETACHED
- R-2 SINGLE FAMILY RESIDENTIAL ATTACHED
- R-3 MULTI-FAMILY APARTMENTS
- B-1 BUSINESS & COMMERCIAL
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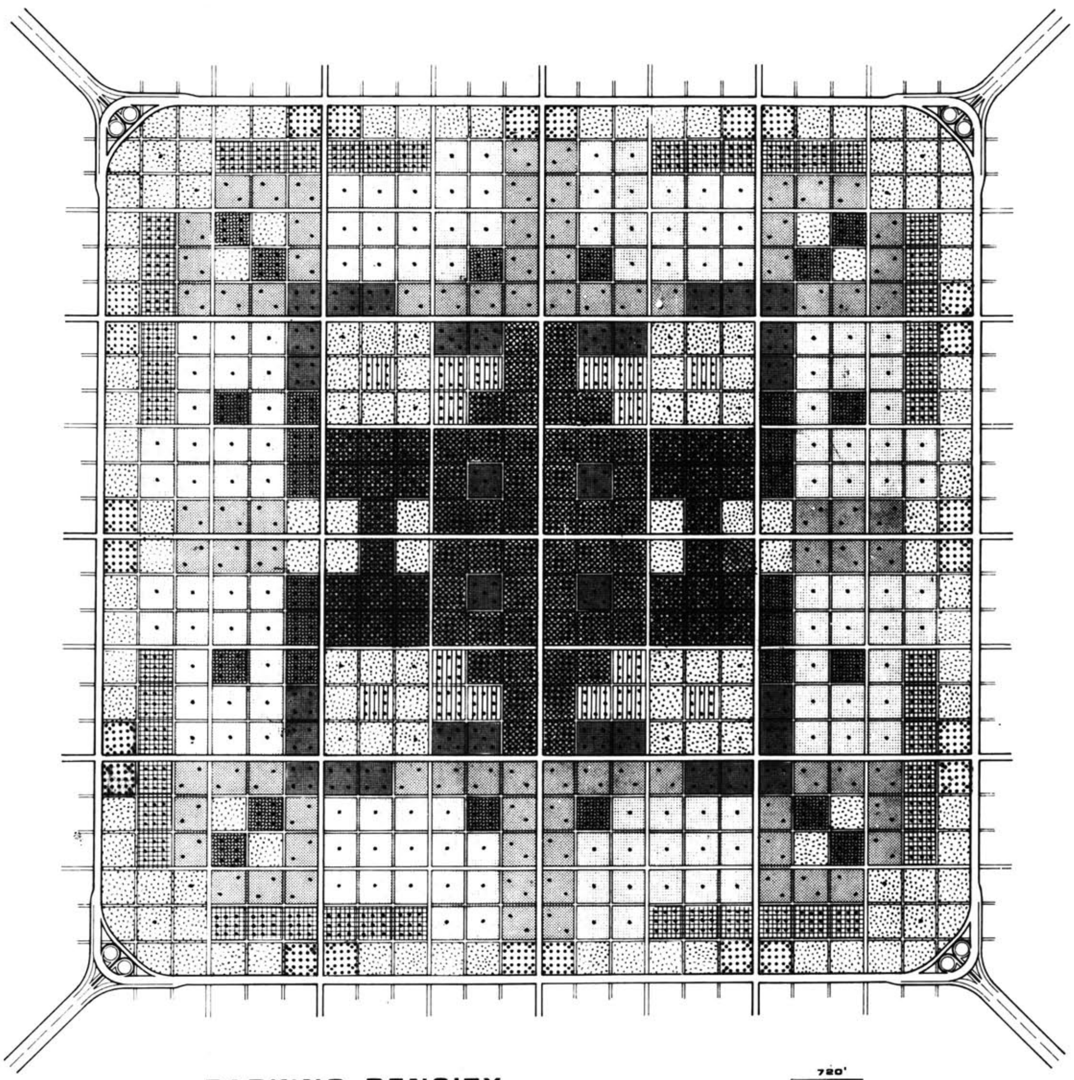
THE CITY AS A SYSTEM

Scheme No. 120



PARKING DENSITY

• : 100 CARS

720'
0 1440'

ZONING:

R-1 SINGLE FAMILY RESIDENTIAL DETACHED	P-1 ADMINISTRATION
R-2 SINGLE FAMILY RESIDENTIAL ATTACHED	P-2 CULTURAL - ENTERTAINMENT
R-3 MULTI - FAMILY APARTMENTS	P-3 EDUCATIONAL
B-1 BUSINESS & COMMERCIAL	P-4 PERIPHERY PARKING
B-2 LIGHT MANUFACTURING	P-5 PARKS - BUFFER ZONE

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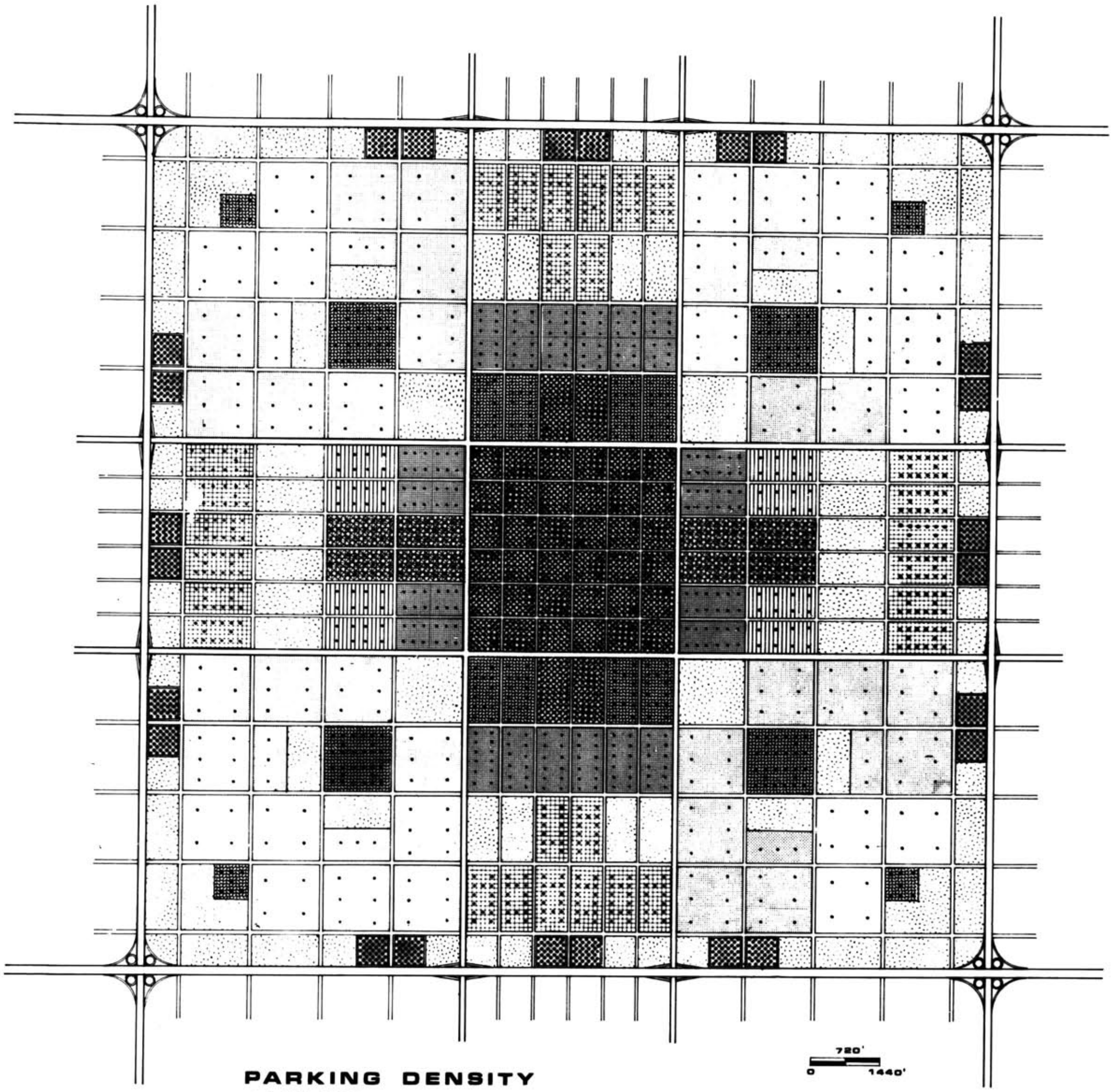
THE CITY AS A SYSTEM

Scheme No. 240



PARKING DENSITY

• : 100 CARS

ZONING:

R-1 SINGLE FAMILY RESIDENTIAL DETACHED	P-1 ADMINISTRATION
R-2 SINGLE FAMILY RESIDENTIAL ATTACHED	P-2 CULTURAL - ENTERTAINMENT
R-3 MULTI-FAMILY APARTMENTS	P-3 EDUCATIONAL
B-1 BUSINESS & COMMERCIAL	P-4 PERIPHERY PARKING
B-2 LIGHT MANUFACTURING & WHOLESALE	P-5 PARKS - BUFFER ZONE

THE CITY AS A SYSTEM
MASTER OF ARCHITECTURE THESIS

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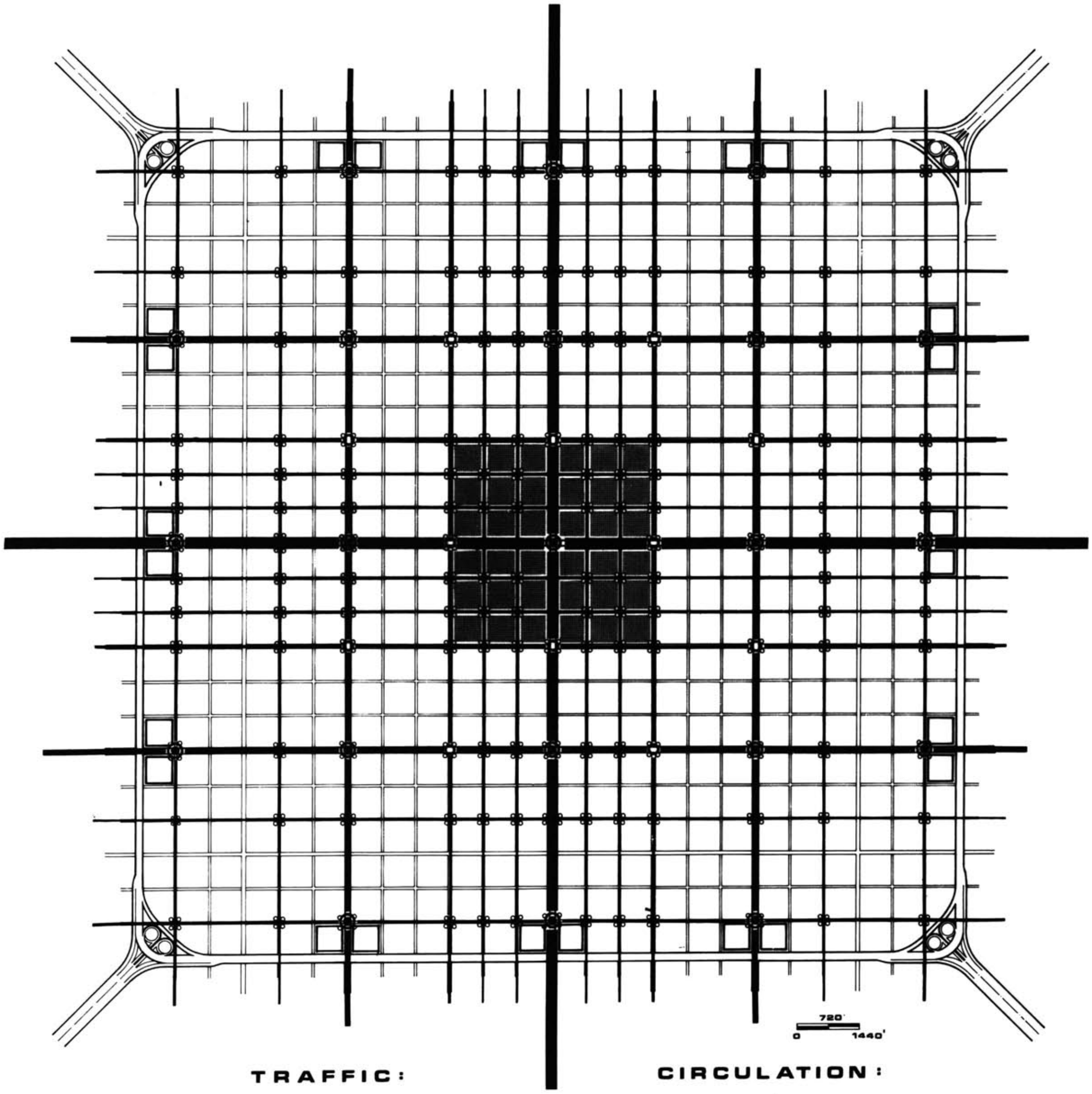
THE CITY AS A SYSTEM

Scheme No. 120



TRAFFIC:

STATION

EXPRESS SUBWAY

LOCAL SUBWAY

MAJOR BUS

CIRCULATION:

GUIDELINE:

REGIONAL RAIL

LOCAL RAIL

BUS LINE

THE CITY AS A SYSTEM
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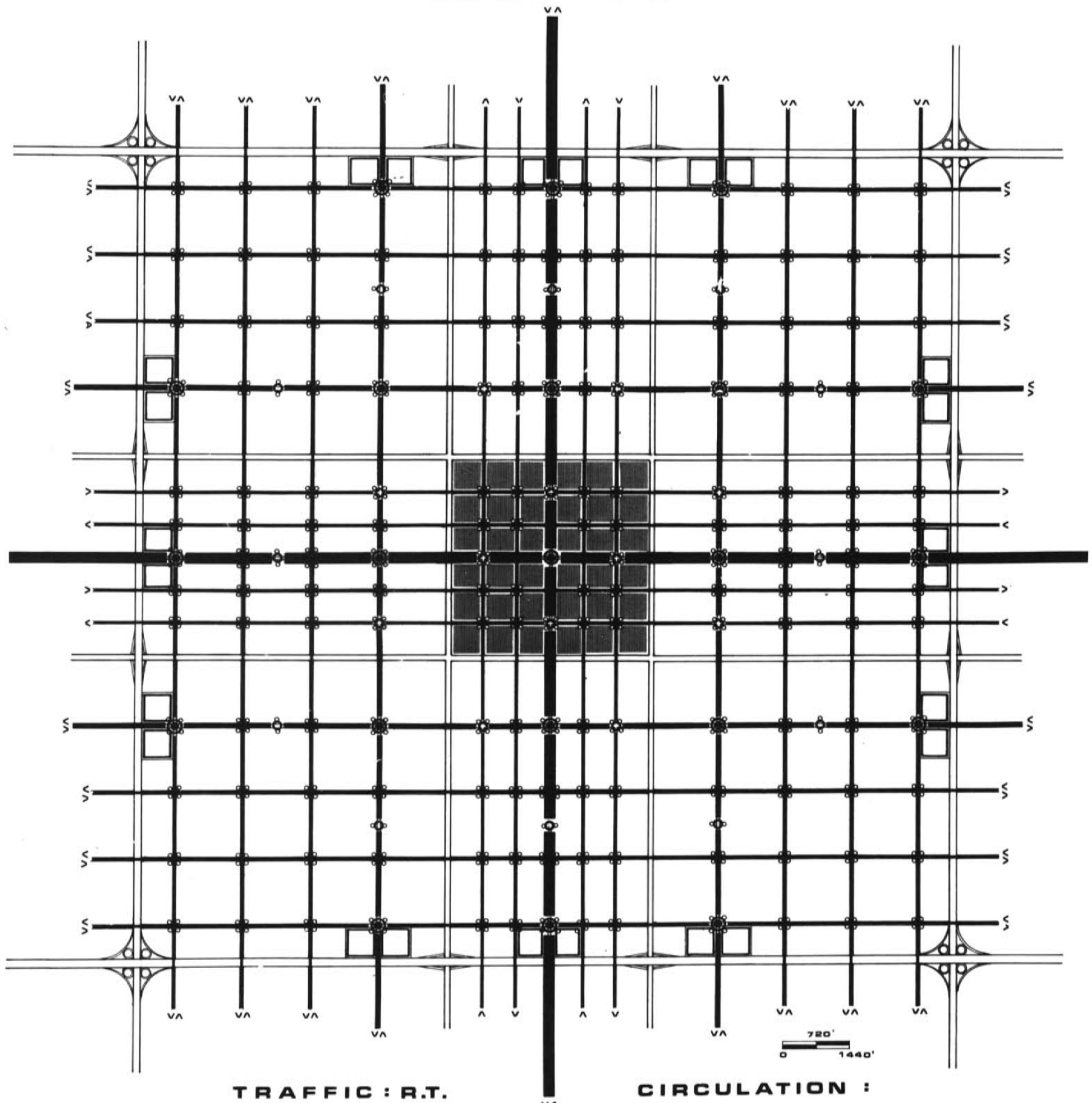
THE CITY AS A SYSTEM

Scheme No. 240



TRAFFIC : R.T.

CIRCULATION :

STATION :

- ◉ EXPRESS SUBWAY
- ○ LOCAL SUBWAY
- ∘ MAJOR BUS STOP

GUIDEWAY :

- REGIONAL RAIL
- LOCAL RAIL
- BUS LINE

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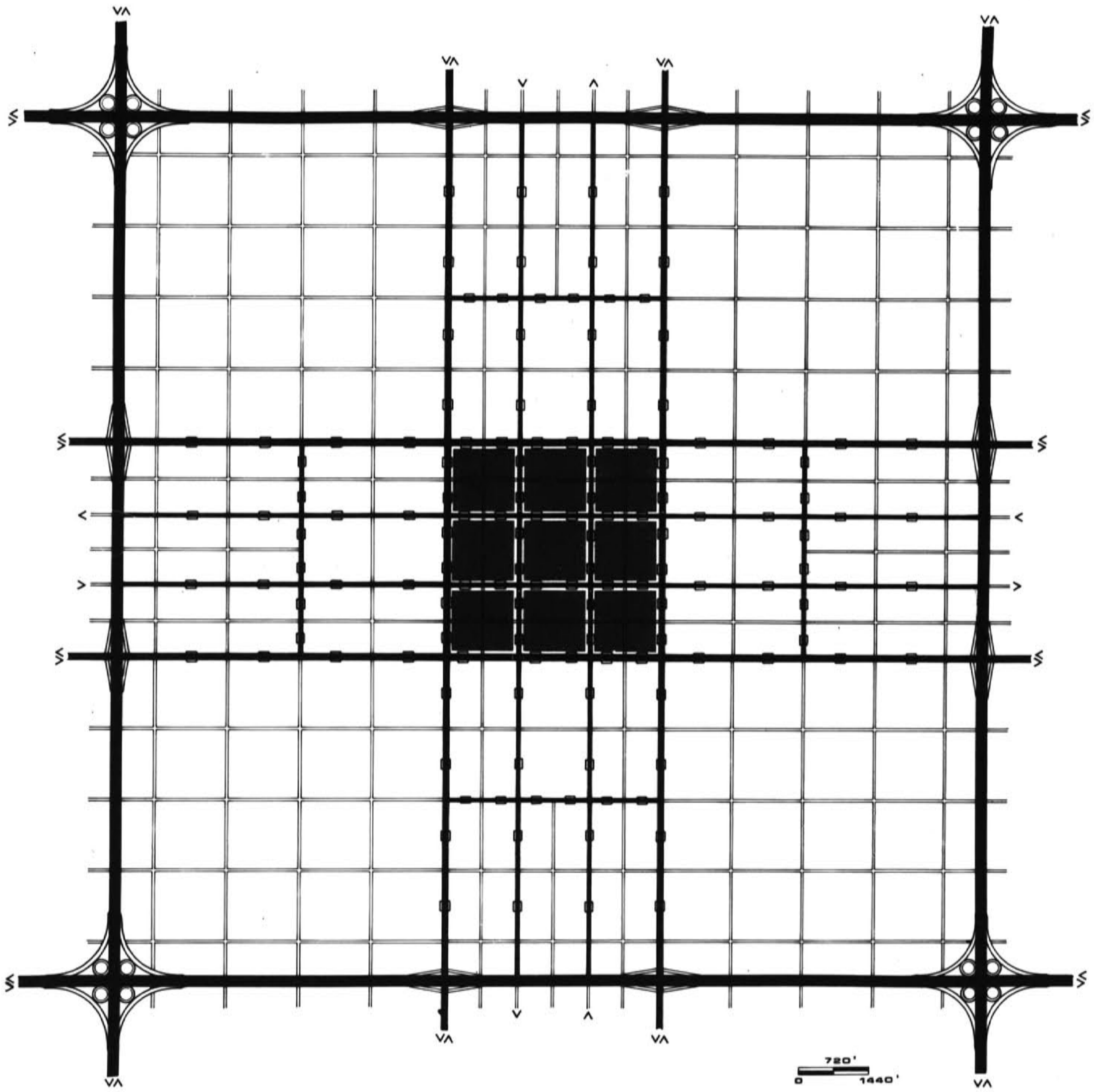

VEHICULAR : AUTO CIRCULATION :

ELEVATED ROADWAY :

4 LEVEL FREEWAY - T.W.

3 LEVEL MAJOR ARTERY - T.W.

3 LEVEL MAJOR STREET - O.W.

SURFACE ROAD :

COLLECTOR STREET - T.W.

VERTICAL ACCESS

C.B.D

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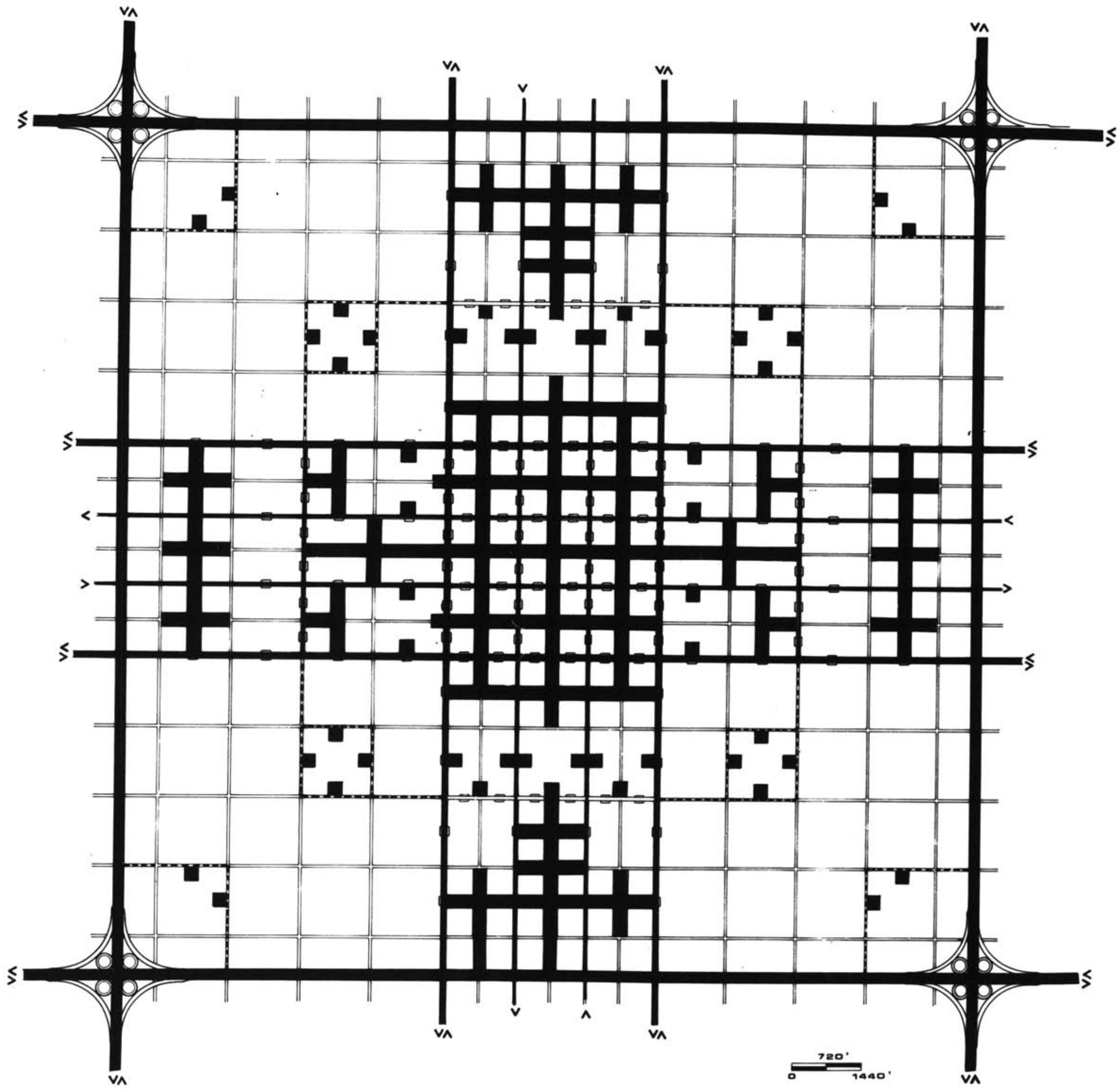

VEHICULAR : TRUCK CIRCULATION

SURFACE ROADWAY :

PRIMARY TRUCK FREEWAY - T.W.

SECONDARY TRUCK ARTERIAL - T.W.

LOCAL COLLECTOR - O.W.

LOADING DOCK ZONES

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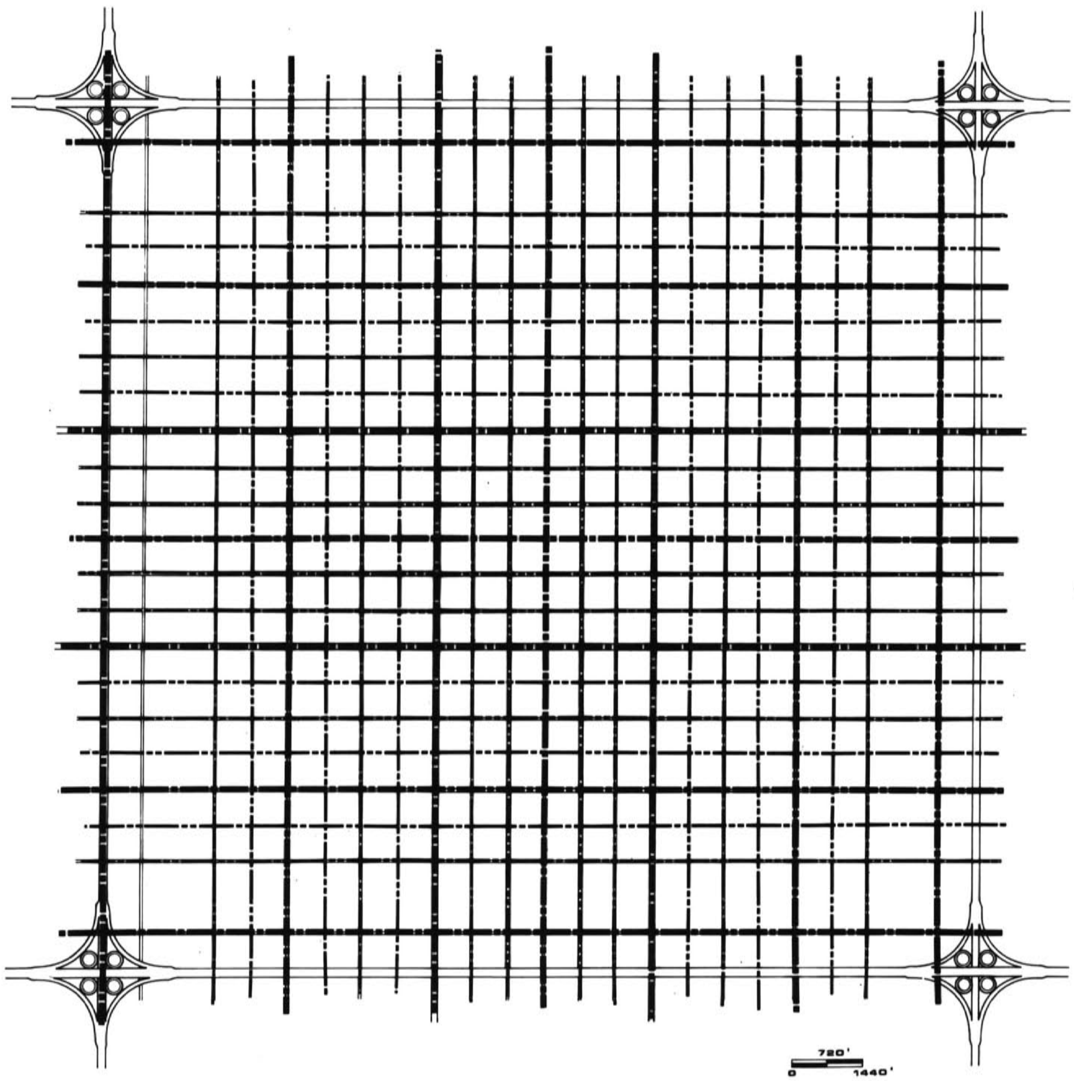

GENERAL UTILITY SERVICES:

GRAVITY SYSTEM: STORM & SEWAGE DRAINAGE

PRESSURE SYSTEM: WATER, GAS & STEAM

POWER SYSTEM: ELECTRICITY & TELEPHONE

MAIN LINE

SECONDARY LINE

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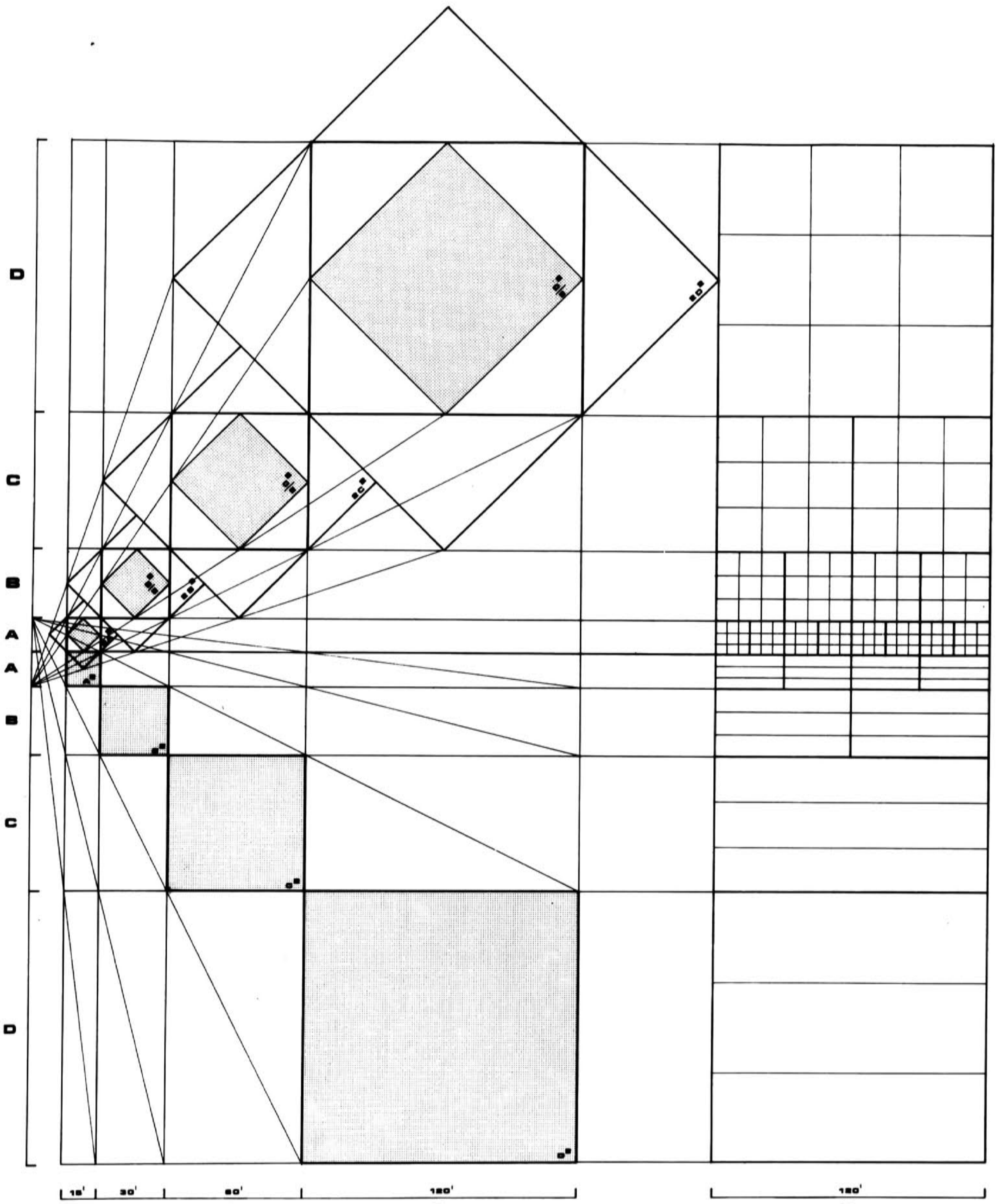

GEOMETRIC GROWTH COORDINATION :

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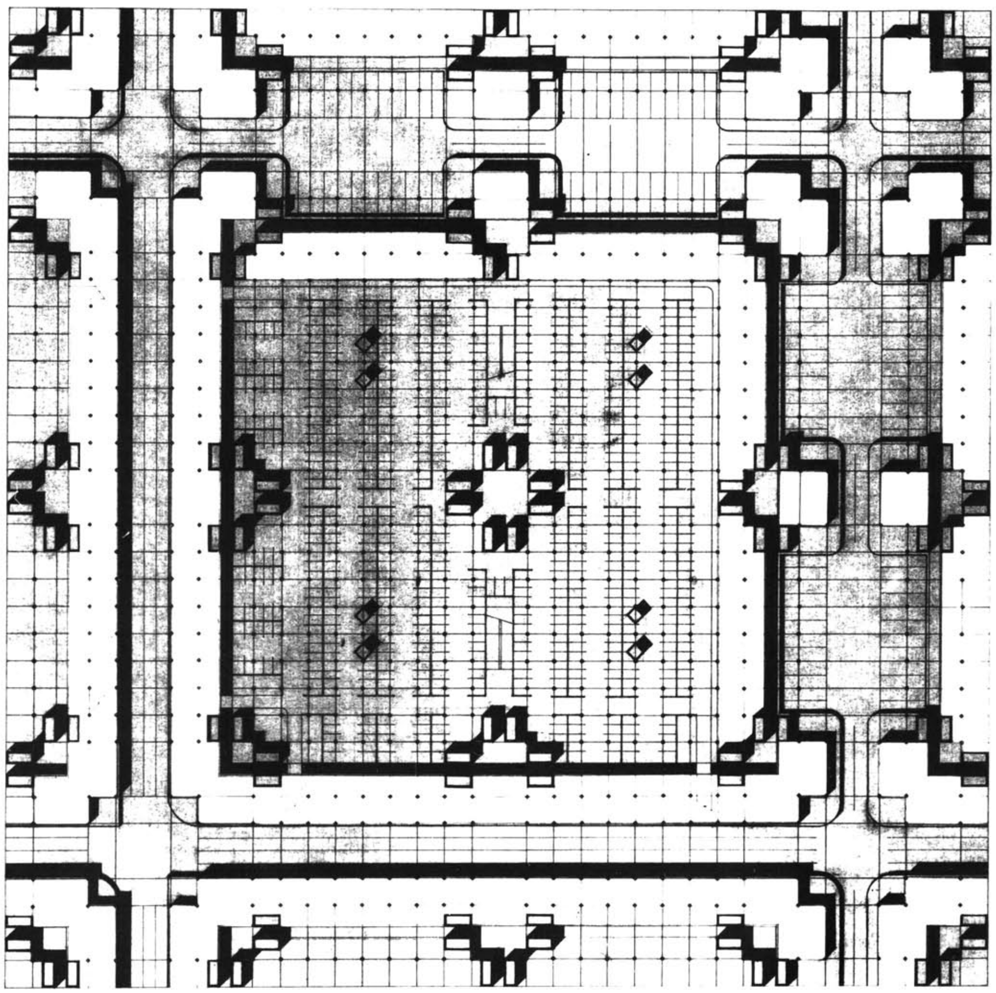

PARKING LEVEL 1 & 2

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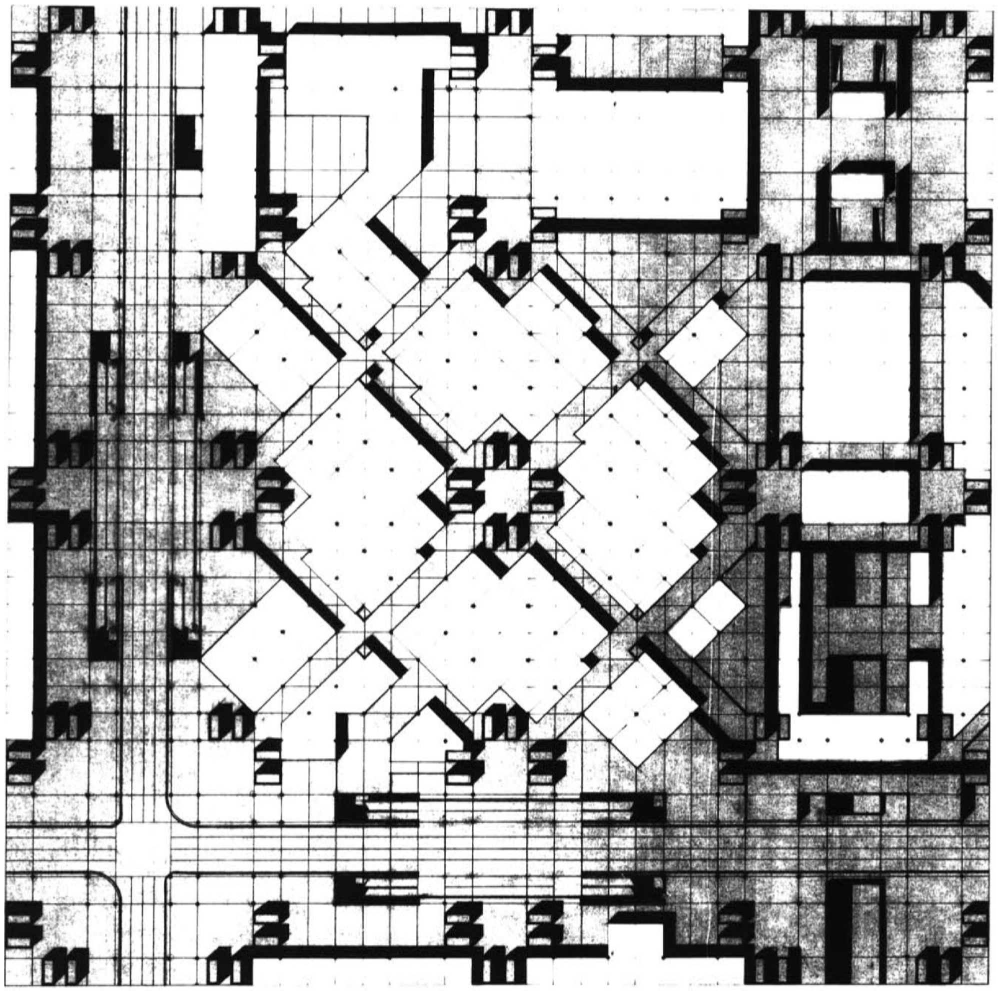

SECONDARY PEDESTRIAN LEVEL :

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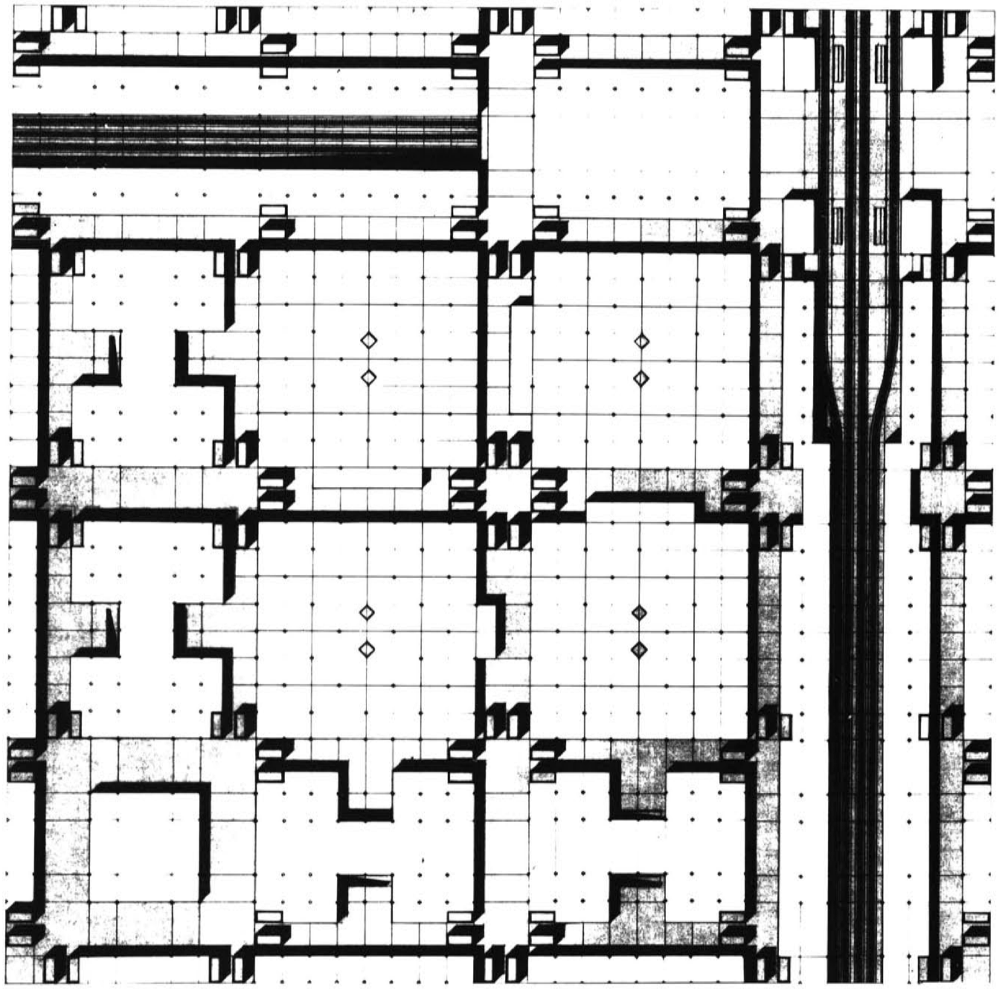

PRIMARY PEDESTRIAN LEVEL :

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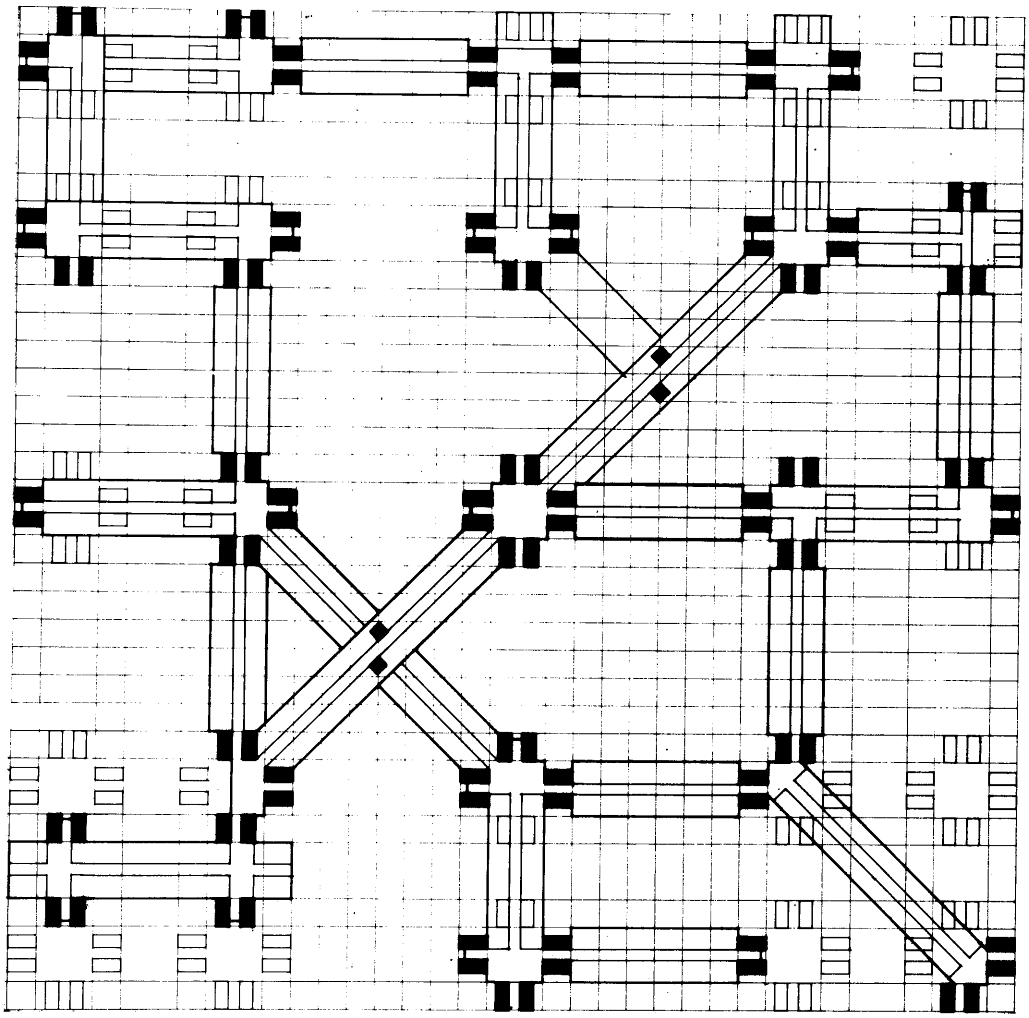
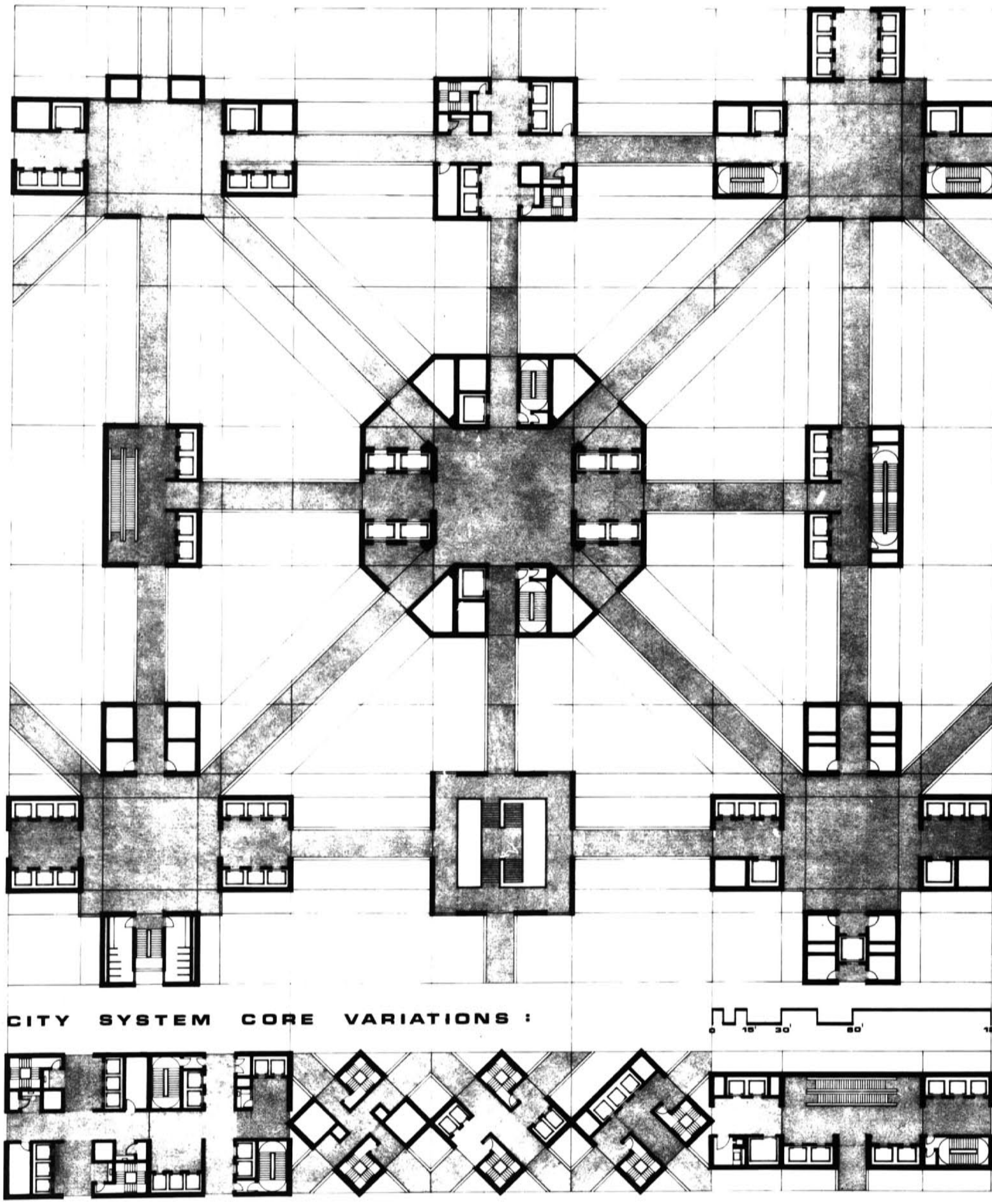


BUILDING - CORE VARIATIONS :

30' 90'
0' 60' 120'

THE CITY AS A SYSTEM



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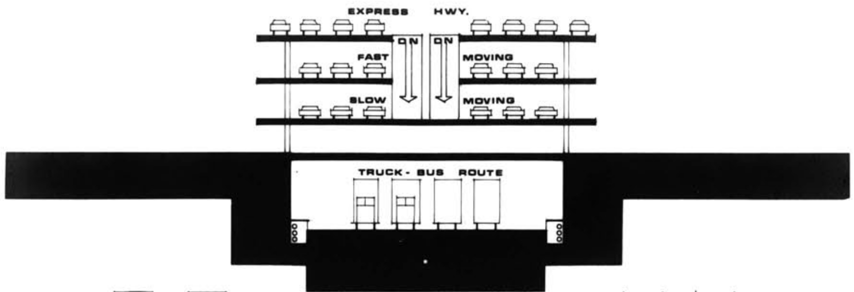
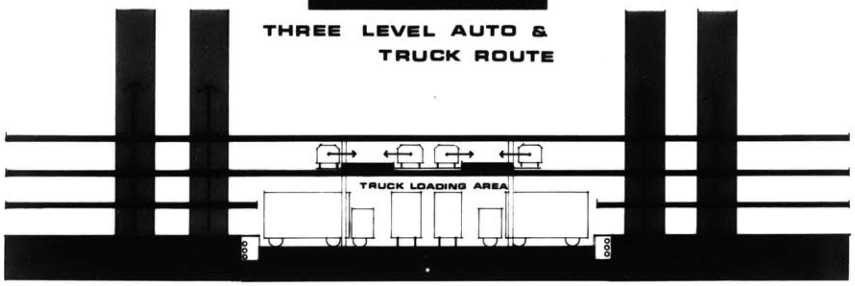
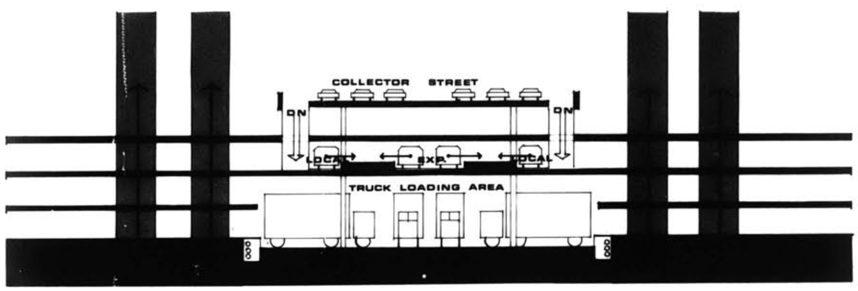


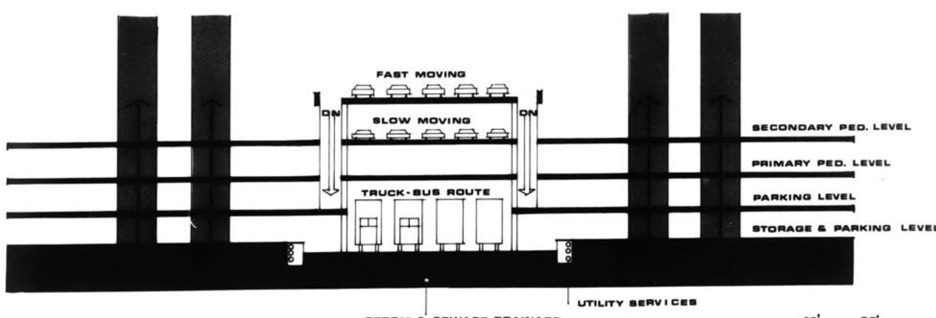
THREE LEVEL AUTO & TRUCK ROUTE



REGIONAL SUBWAY & TRUCK ROUTE



LOCAL SUBWAY & ONE LEVEL AUTO



TWO LEVEL AUTO & TRUCK-BUS ROUTE

SECTION VARIATIONS

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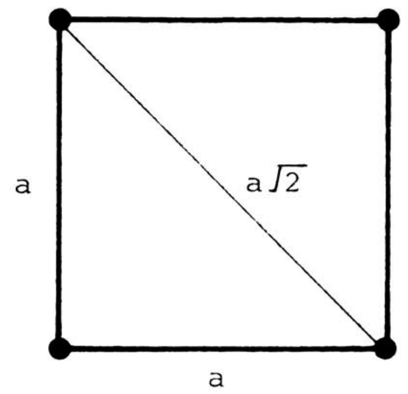
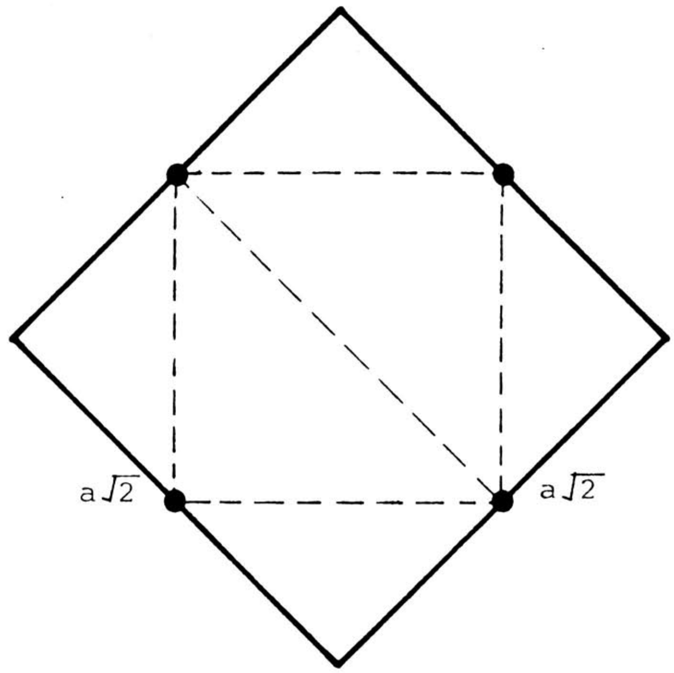
STRUCTURAL & GEOMETRICAL VARIATIONS OF THE CITY BUILDING SYSTEM

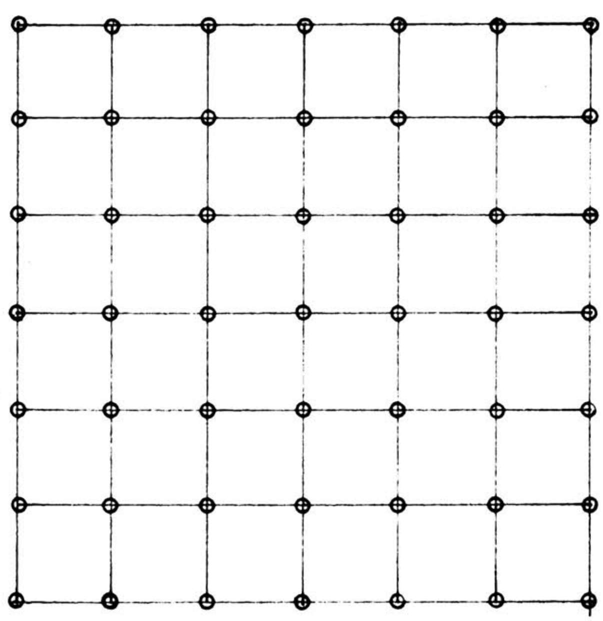
ROTATION OF THE STRUCTURAL AND PLANNING GEOMETRY:



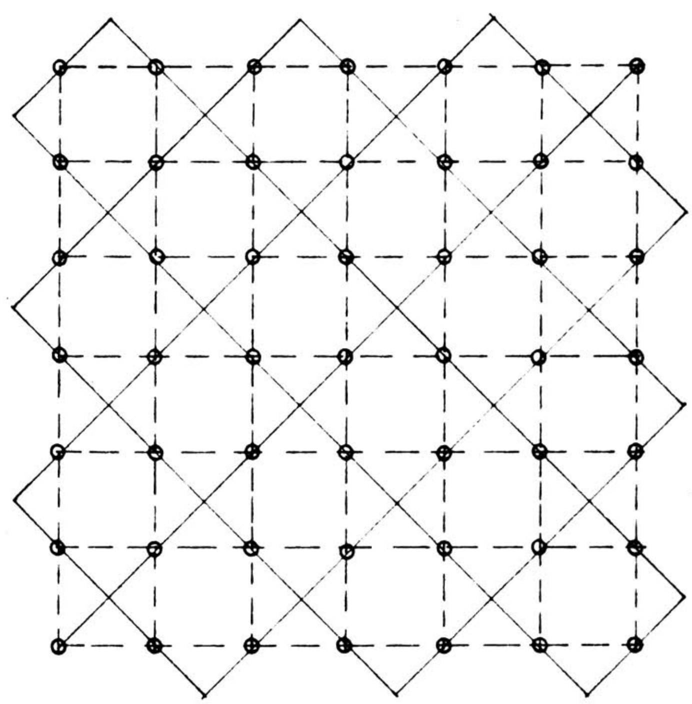
AREA = a^2



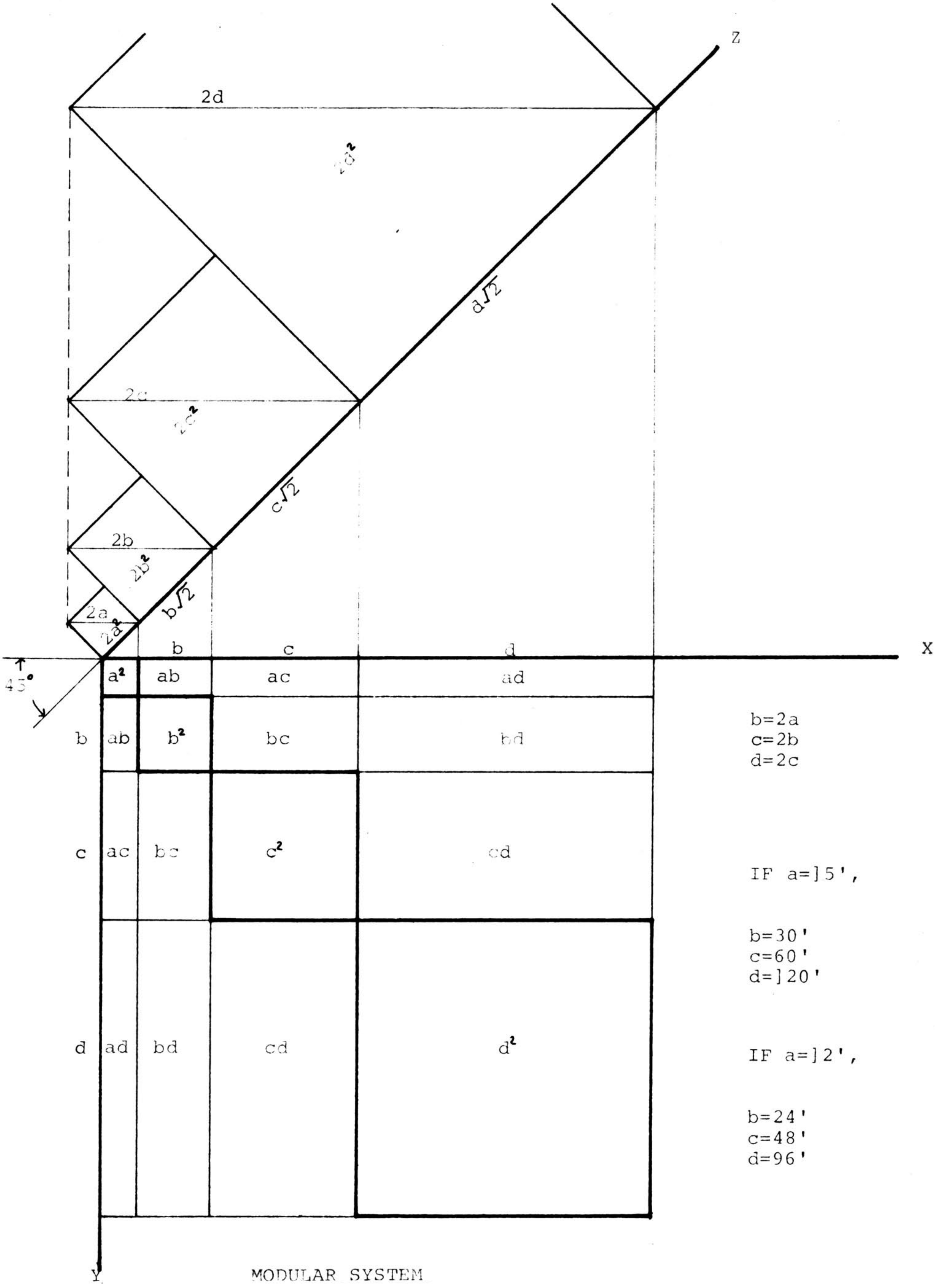
AREA = $2a^2$



ORTHOGANAL GEOMETRY

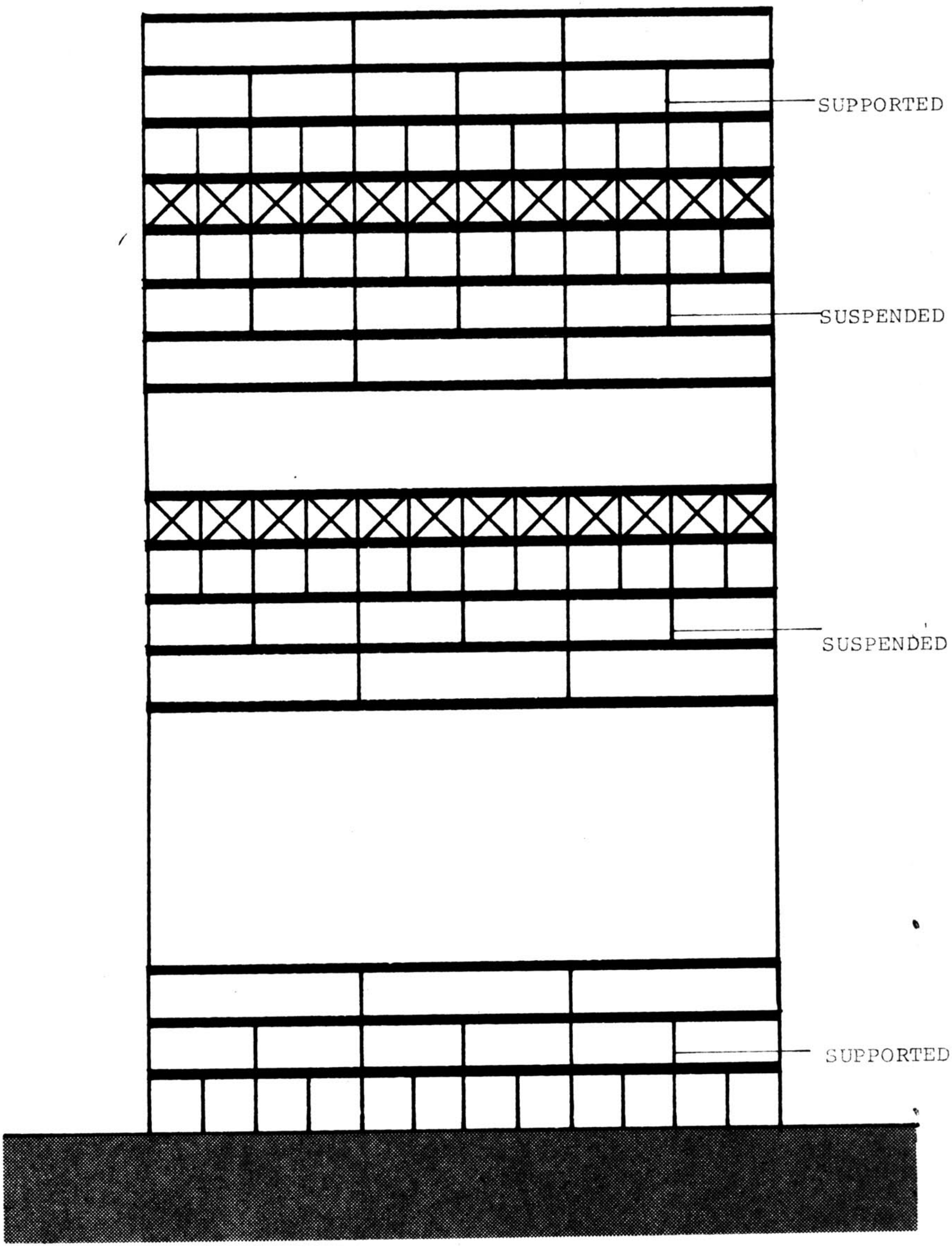


ROTATED ORTHOGANAL GEOMETRY



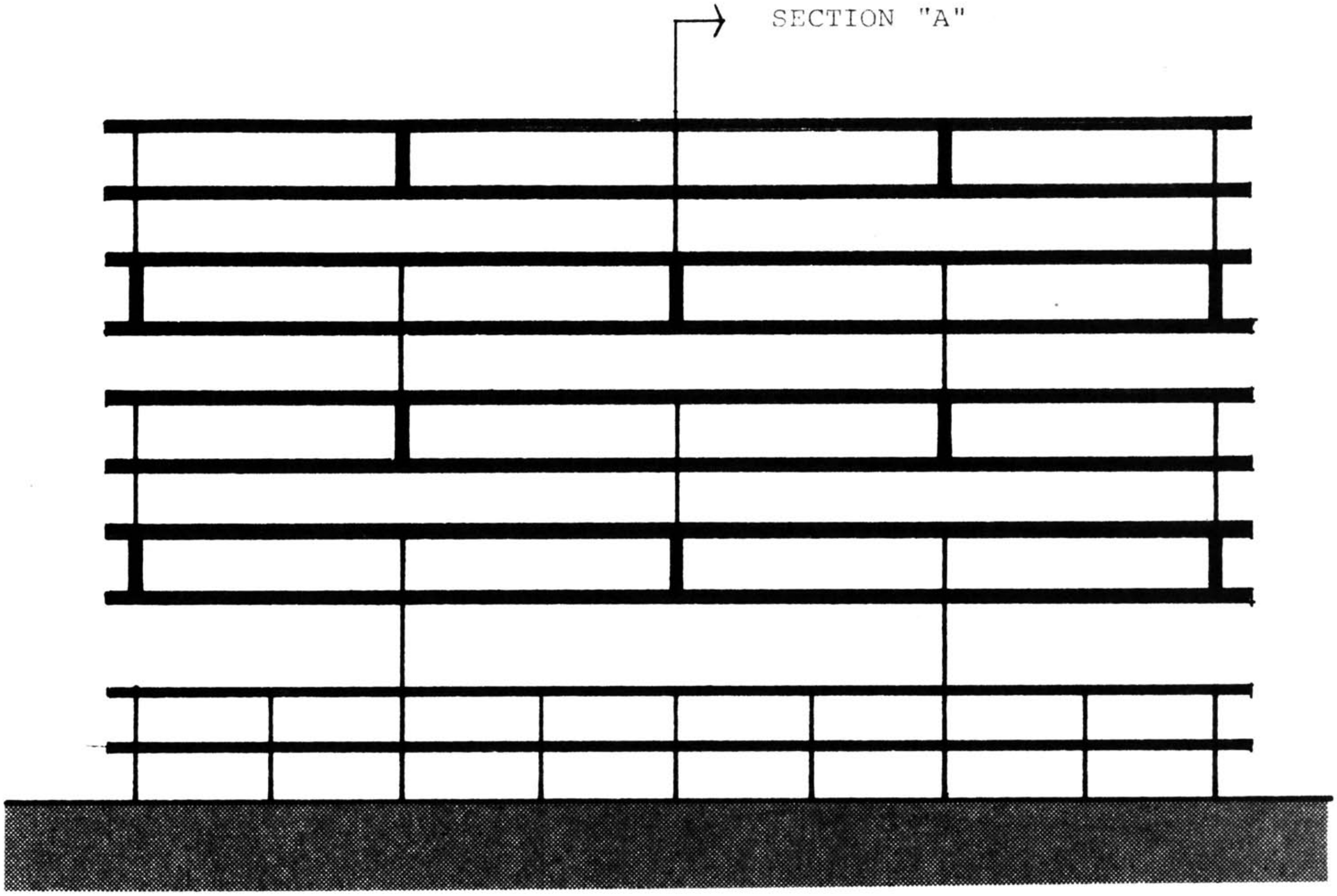
MODULAR SYSTEM

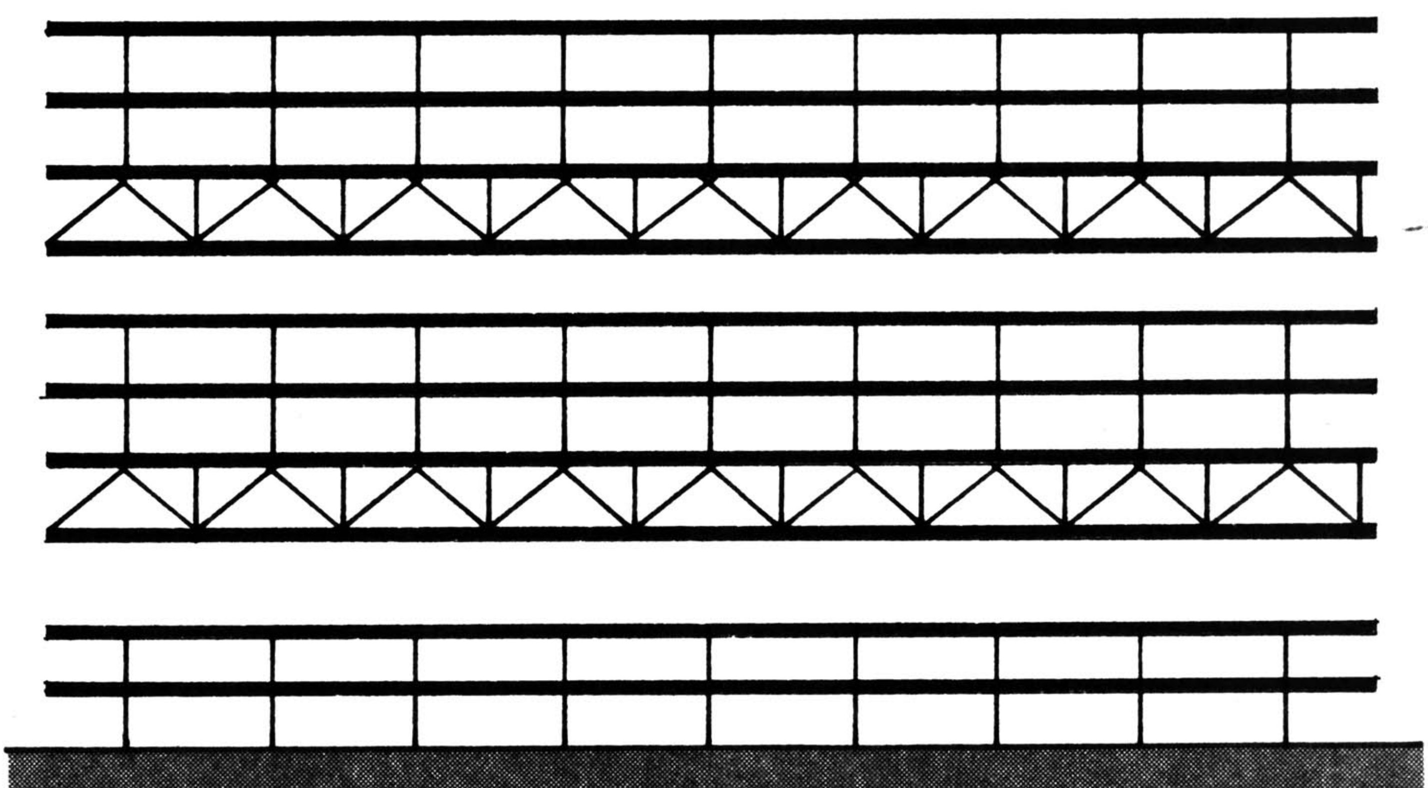
STRUCTURAL VARIATIONS - COLUMN AND SUSPENSION SYSTEM:



SCALE: 1"=40'-0"

STRUCTURAL VARIATIONS - DOUBLE STAGGERED TRUSS SYSTEM:





COMPUTER APPLICATION TO THE CITY SYSTEM MODEL

Computer Application to the City System Model:

The purpose of this chapter is to provide an explicit reference point for the use of computers as an aid to both city planners and architects. It is a brief, but critical attempt to employ the use of computers in its rightful potential -- as a tool to generate the complex number of variable requirements into a viable set of working alternatives. This simply means that a wide number of considerations can be tested, their implications and impact evaluated, and an optimum solution can be established based on the resources available and the overall goals to be achieved.

The approach in this problem was to choose and implement the already available, and most economical method of a planar matrix analysis to develop a variable City System Model. This model would eventually have the basic following characteristics or program objectives:

1. It would be the traditional orthogonal planar model using the principle x axis (column) and y axis (row) to establish the relationships of a singular matrix analysis unit. It is assumed that this unit would represent an assumed area. In our case, it was a 720' square block that was chosen for the City System Model -- it permitted what we felt was the minimum analysis unit for a City System Model at the scale we were dealing with. It represented about 14 square miles, or 576 matrix units (24 x 24) to provide enough area for a Central City Core supporting a population of 1,200,000.

   The obvious continuation of this approach is immediately into matrix planes for linear cities; then random growth patterns; and finally, irregularly shaped matrix patterns which resemble the types of analysis areas for existing cities today.

2. Secondly, the City System Model bases its approach of studying the idea of a city not in specifics, but in terms of "permanent variables" which persist over time and are directly applicable to any city we may desire to develop or analyze. These permanent variables were established in the following categories:

1.) Population Density

2.) Employee Density

3.) Volumetric Density

4.) Parking Density

5.) Floor Area Ratio

Each of the above major variables are themselves differentiated by sub-variables particularly characteristic of the City System being evaluated. The Fortran Program which has yet to be fully developed, is composed of the following equations and variables, and constants which reflect the depth and interdependency of the "permanent variables":

A. Main Variables:

% of people live in the center city = P.P.C.C.T.

% of employees in the center city = P.E.C.C.T.

% of people use car = P.P.U.C.R.

B. Sub-Variables:

% of center city people live in the district = P.P.D.T.

% of center city employees in the district = P.E.D.T.

No. of blocks in the district = N.B.K.D.T.

No. of people/dwelling unit = N.P.P.D.U.

No. of people/car = N.P.P.C.R.

Required average sq. ft./dwelling unit	=	S.F.P.D.U.
Average required sq. ft./customer car	=	R.S.F.P.C.R.
Average required sq. ft./employee	=	R.S.F.P.E.

C. <u>Constants:</u>

Total population of city	=	T.P.C.	=	1,200,000 P.
Total employees of city	=	T.E.C.	=	480,000 E.
No. of blocks in the center city	=	N.B.C.C.T.	=	576 B.K.
Required sq. ft./car	=	S.F.P.C.R.	=	350 S.F.
One acre	=	A.C.	=	43,560 S.F.
One block	=	B.K.	=	518,400 S.F.
Block/acre	=	B.P.A.	=	11.9
Average No. of employees/car	=	N.E.P.C.R.	=	2 E.

D. <u>Permanent Variable Equations:</u>

a. Population Density--

No. of people in the district	=	N.P.D.T.	=	P.P.D.T.*P.P.C.C.T.*T.P.C.
No. of people/block	=	N.P.P.B.K.	=	N.P.D.T./N.B.K.D.T.
No. of people/acre	=	N.P.P.A.C.	=	N.P.P.B.K./B.P.A.

b. Employee Density--

No. of employees in the district	=	N.E.D.T.	=	P.E.D.T.*P.E.C.C.T.*T.E.C.
No. of employees/blk.	=	N.E.P.B.K.	=	N.E.D.T./N.B.K.D.T.
No. of employees/acre	=	N.E.P.A.K.	=	N.E.P.B.K./B.P.A.

c. Volumetric Density--

Total parking area in sq. ft.	=	P.K.S.F.	=	N.C.R.*S.F.P.C.R.
Dwelling unit area in sq. ft.	=	D.U.S.F.	=	N.D.U.*S.F.P.D.U.

Employee required area in sq. ft.	=	E.R.S.F.	= N.E.*R.S.F.P.E.
Total sq. ft. in the district	=	T.S.F.D.T.	= P.K.S.F. + D.U.S.F. + E.R.S.F.
Floor sq. ft./blk.	=	S.F.P.B.K.	= T.S.F.D.T./N.B.K.D.T.
Floor sq. ft./acre	=	S.F.P.A.C.	= S.F.P.B.K./B.P.A.

d. Parking Density--

Residential parking requirement	=	R.P.R.	= N.D.U.D.T.*N.C.R. P.D.U.
Employees parking requirement	=	E.P.R.	= $\frac{\text{N.E.*P.P.U.C.R.}}{\text{N.E.P.C.A.R.}}$
Customer parking requirement	=	C.P.R.	= $\frac{\text{T.S.F.D.T.}}{\text{R.S.F.P.C.R.}}$
No. of cars/block	=	N.C.R.P.B.K.	
	=	$\frac{\text{(R.P.R. + E.P.R. + C.P.R.)}}{\text{N.B.K.D.T.}}$	
No. of cars/acre	=	N.C.R.D.A.C.	= N.C.R.P.B.K./B P.A.

e. Floor Area Ratio-- = F.A.R. = S.F.P.B.K./518,400 S.F.

Definition of Symbols

P. --- people

B.K. --- block

E. --- employee

S.F. --- sq. ft.

% --- should be expressed by--example: 20% = .2

Each variable should have symbols.

Example: No. of blocks in the districts

N.B.K.D.T. = 48 B.K.

3. Thirdly, this City System Model is directly related to the phenomena of "change" and "growth" of a city over a period of time. Since this approach was to have two facets to the program -- it would be very easy to convert quantitative results, and convert them into a visual representation which would convey the total picture to the designer in a significant and interactive response to the designer city system analyst. This basic approach was confirmed and given constant impetus by the two sole sources of help, advice, and enthusiasm -- Mr. Timothy Johnson (M. I. T. instructor in Architectural Fortran Programming) and Mr. Allan Schmidt (Assistant Director at Harvard's Computer Graphics Department for Architecture and City Planning).

The approach was made tentatively feasible by synthesizing two operational programs available. The first is the normal Fortran IV language system which can handle and generate all numeric and quantitative values of the City System Model. The second program is called Symap, provided under the auspices of Mr. Allan Schmidt, which gives a simple 10-option overprint value system to convert the values into a variable graphic system. The immediate results provided are the following:

1.) The Fortran program which generated the 24 x 24 cell matrix city model and the corresponding distances between cells to represent a hierarchy of street patterns from a major arterial, to a major street, to a collector, and finally a local street. This program was developed with Mr. Allan Schmidt of Computer Graphics, with most of the credit and wisdom being gladly given here to Mr. Schmidt.

The second phase would be to correlate the program for the analysis of the "permanent variables" to the matrix system. It also can be generated on a vertical isometric surface model by a cathode ray tube and photographed on microfilm for reproduction. This would give a simple but explicit visual terrain of the demographic material to be presented.

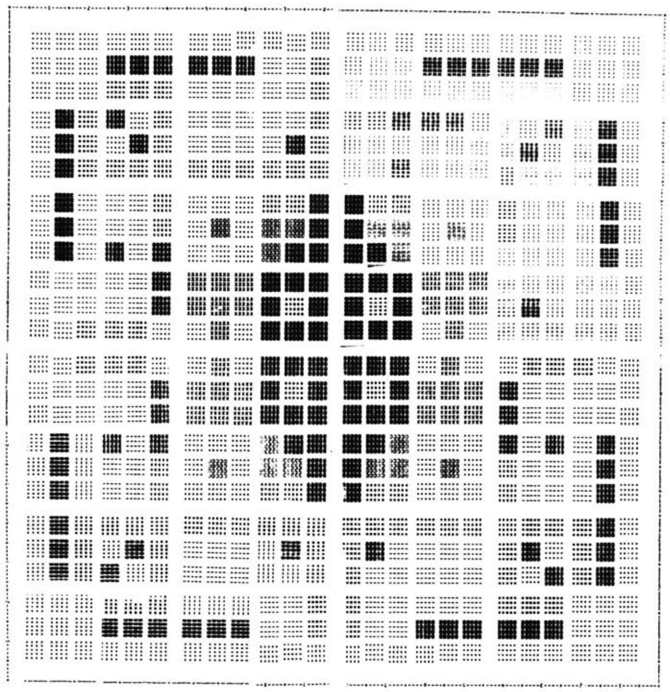
2.) The second sheet is a graphic output for the ten various Zoning Areas we felt were required for a visual City System Model. The values chosen were basically categorized to symbolically represent the intensity level of the usage within each zone. From P 1 to P 5 for Public Zones and Service Areas; B 1 to B 2 for Business and Commercial Areas; and finally, R 1 to R 3 for the Residential Areas. The plate shown gives the visual form for both No. 120 and No. 240. They are both different in circulation patterns; and, No. 240 represents a corrected and more sensitive approach to the total problem of a City System Model.

Conclusion:

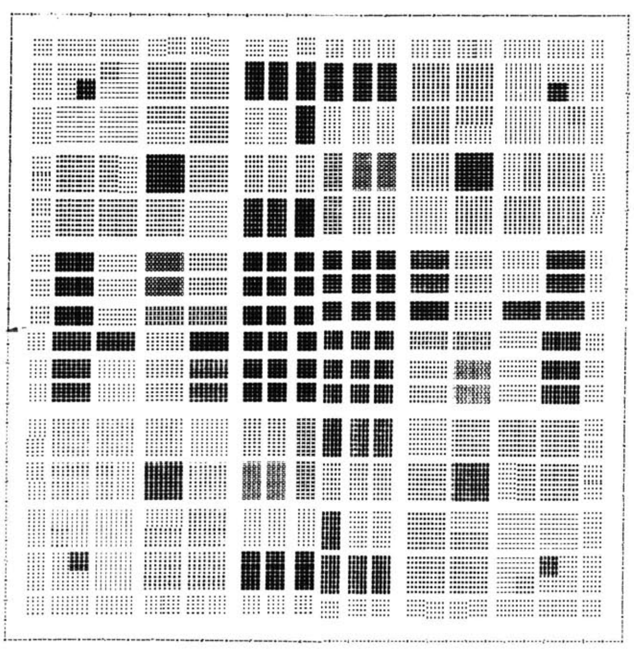
Once this City System Model is developed properly, it will give us a valuable tool which can handle complex interactions and input data on a scale much too difficult to do by hand. The operations can be reduced from weeks of time per option to just a few hours at the most. As a tool to gladly reduce designer's "fatigue" and give him time to evaluate alternatives properly, this approach is a welcome and useful change. The authors certainly appreciate the help offered, of which this chapter would only remain a hesitant guess and determined piece of wishful thinking. It now remains to be carried further by those generations who realize the validity of this approach to carry this work to its rightful place as a designer's tool.

```
      SUBROUTINE FLEXIN (IFORM, T, FIRST)                                ...
      DIMENSION X(24), Y(24), C(12), F(12), T(4)                         ...
       LOGICAL FIRST                                                     ...
      DATA NCOL/0/, I/0/, ICOUNT/0/,B/0.5/,E/0.5/                        ...
      GO TO (1,2,3), IFORM                                               ...
    1 IF (.NOT.FIRST) GO TO 20                                           ...
C     AND F CARDS CONTAIN VALUES FOR THE STREET PATTERN                  ...
      READ (5,600) C,F                                                   ...
  600 FORMAT (12F5.0,/,12F5.0)                                           ...
      THIS IS A DO LOOP WHICH GENERATES COORDINATES FOR THE UPPER LEFT H...AND
      CORNERS OF THE MATRIX CELLS - EACH CELL IS 720 FEET BY 720 FEET    ...
    5 DO 10 N = 1,12                                                     ...
      IF(N.NE.1) GO TO 6                                                 ...
      X(1) AND Y(1) ARE UPPER LEFT COORDINATES OF THE 1ST CELL           ...
      X(1) = 0.55                                                        ...
      Y(1) = 0.57                                                        ...
      GO TO 10                                                           ...
    6 A = X(N-1)                                                         ...
      D = Y(N-1)                                                         ...
      M = MOD(N,12)                                                      ...
      IF (M.EQ.0) M=12                                                   ...
      A= X COORDINATE OF THE UPPER LEFT CORNER OF THE PRIOR CELL, B = CE...LL WIDTH
      C(M) = STREET WIDTH. D,E,F(M) ARE ANALAGOUS FOR THE X COORDINATE.  ...
      X(N) = A + B + C(M)                                                ...
      Y(N) = D + E + F(M)                                                ...
   10 CONTINUE                                                           ...
   20 I = I + 1                                                          ...
      ICOORD = MOD(I,4)                                                  ...
      IF (ICOORD .EQ. 0) ICOORD = 4                                      ...
      GO TO (100, 200, 300, 400), ICOORD                                 ...
      100 TO 200 GENERATES THE UPPER LEFT HAND COORDINATES FOR 144 AREAS...
  100 ICOUNT = ICOUNT + 1                                                ...
      NROW = MOD (ICOUNT,12)                                             ...
      IF (NROW.EQ.0) NROW = 12                                           ...
      IF (NROW.EQ.1) NCOL = NCOL + 1                                     ...
      T(1) = Y(NROW)                                                     ...
      T(2) = X(NCOL)                                                     ...
      ROW = T(1)                                                         ...
      COL = T(2)                                                         ...
      RETURN                                                             ...
  200 T(1) = ROW                                                         ...
      200 TO 400 GENERATES COORDIANATES FOR UR,LR,LL CORNERS OF THE CELL...S
      T(2) = COL + B                                                     ...
      RETURN                                                             ...
  300 T(1) = ROW + B                                                     ...
      T(2) = COL + E                                                     ...
       RETURN                                                            ...
  400 T(1) = ROW + B                                                     ...
      T(2) = COL                                                         ...
      RETURN                                                             ...
      DATA IS READ IN SERIES OF STATEMENTS THAT MAKE IT POSSIBLE TO READ... DATA
      FROM DATA BANK CONTAINING DATA FOR THE 24 BY 24 CELL MATRIX        ...
    2 READ(5,500)XCOL,XROW,ZON120                                        ...
  500 FORMAT(2(1X,A4),F5.0)                                              ...
      T(1) = ZON120                                                      ...
```

THE CITY AS A SYSTEM



NO.120



NO.240

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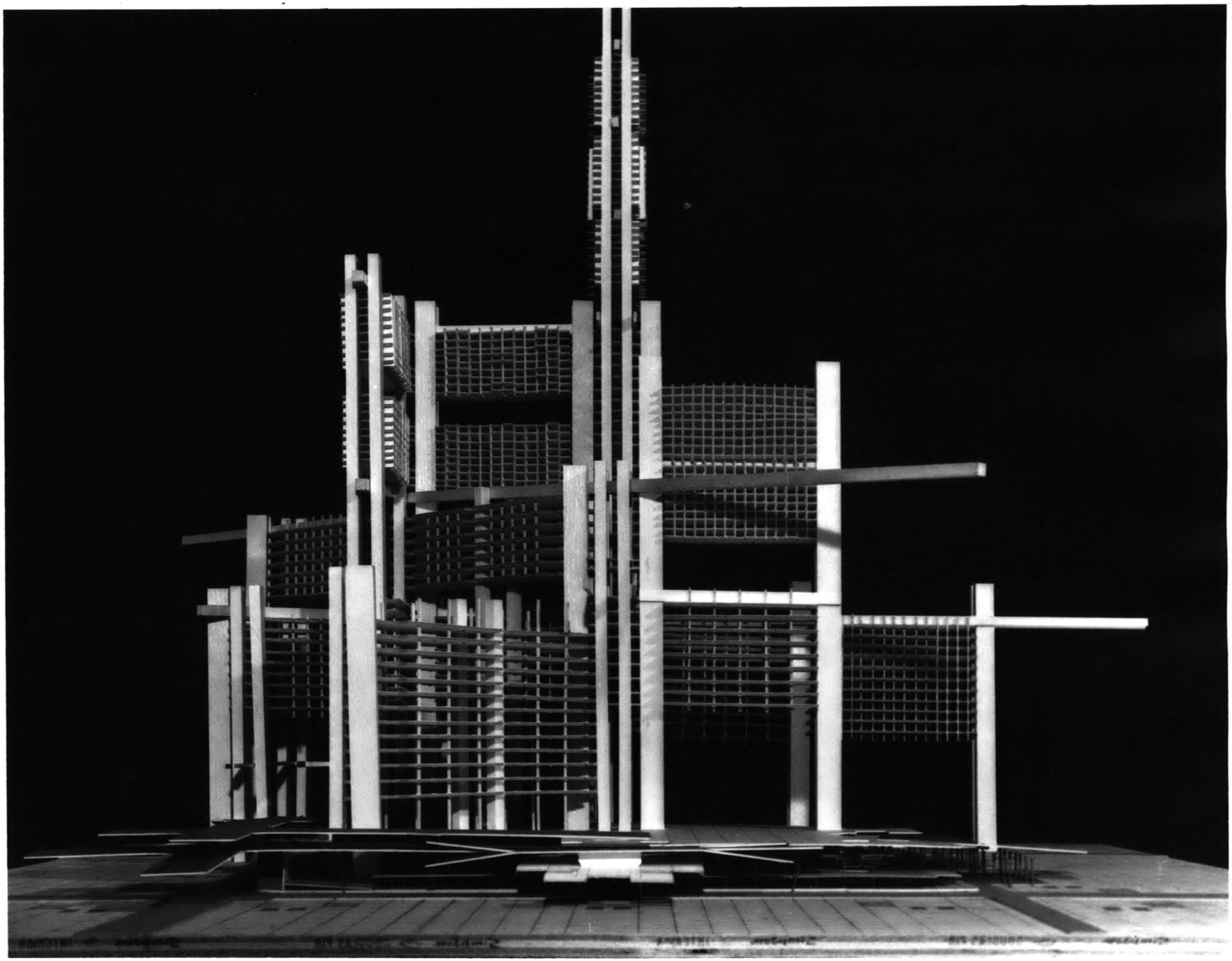
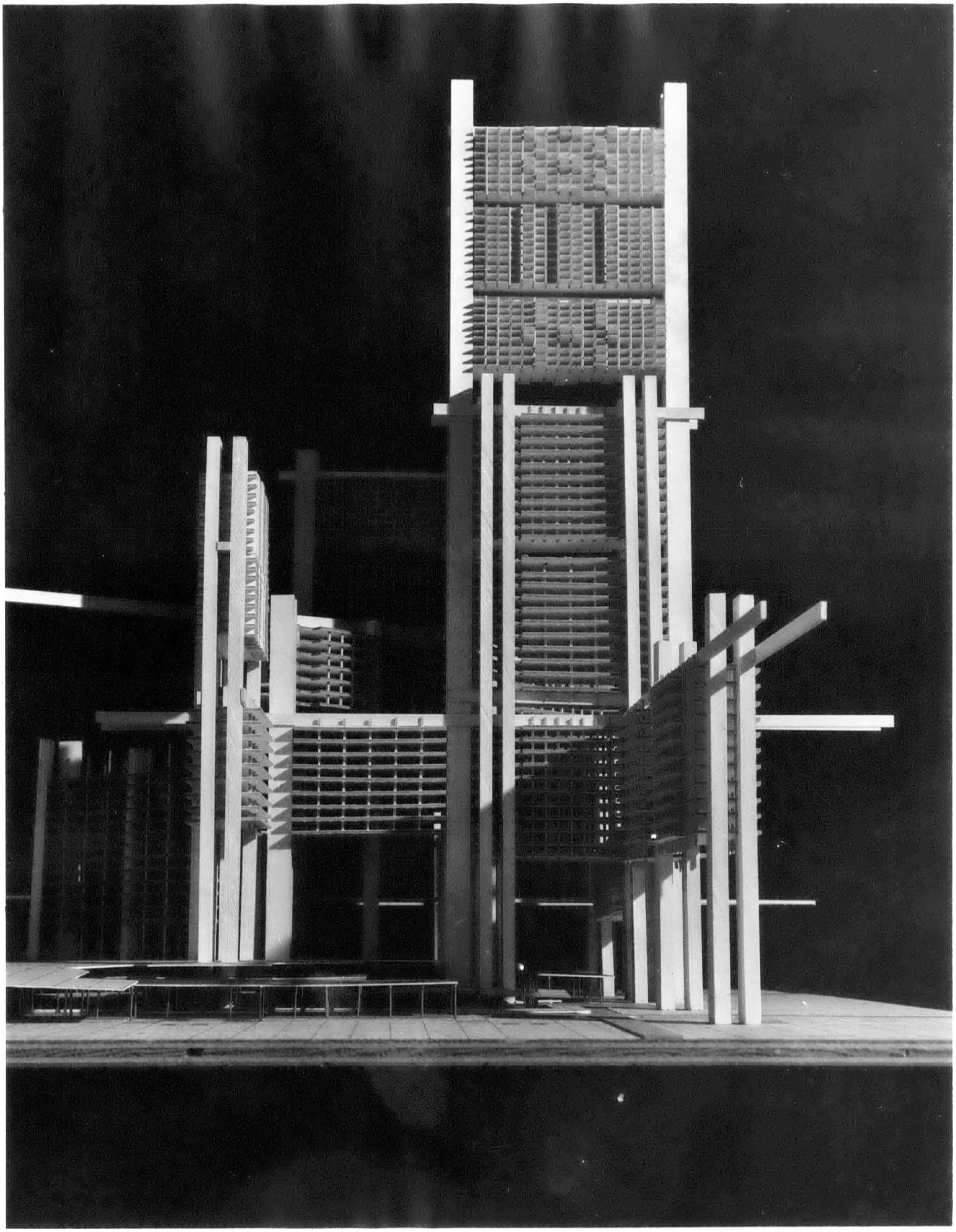
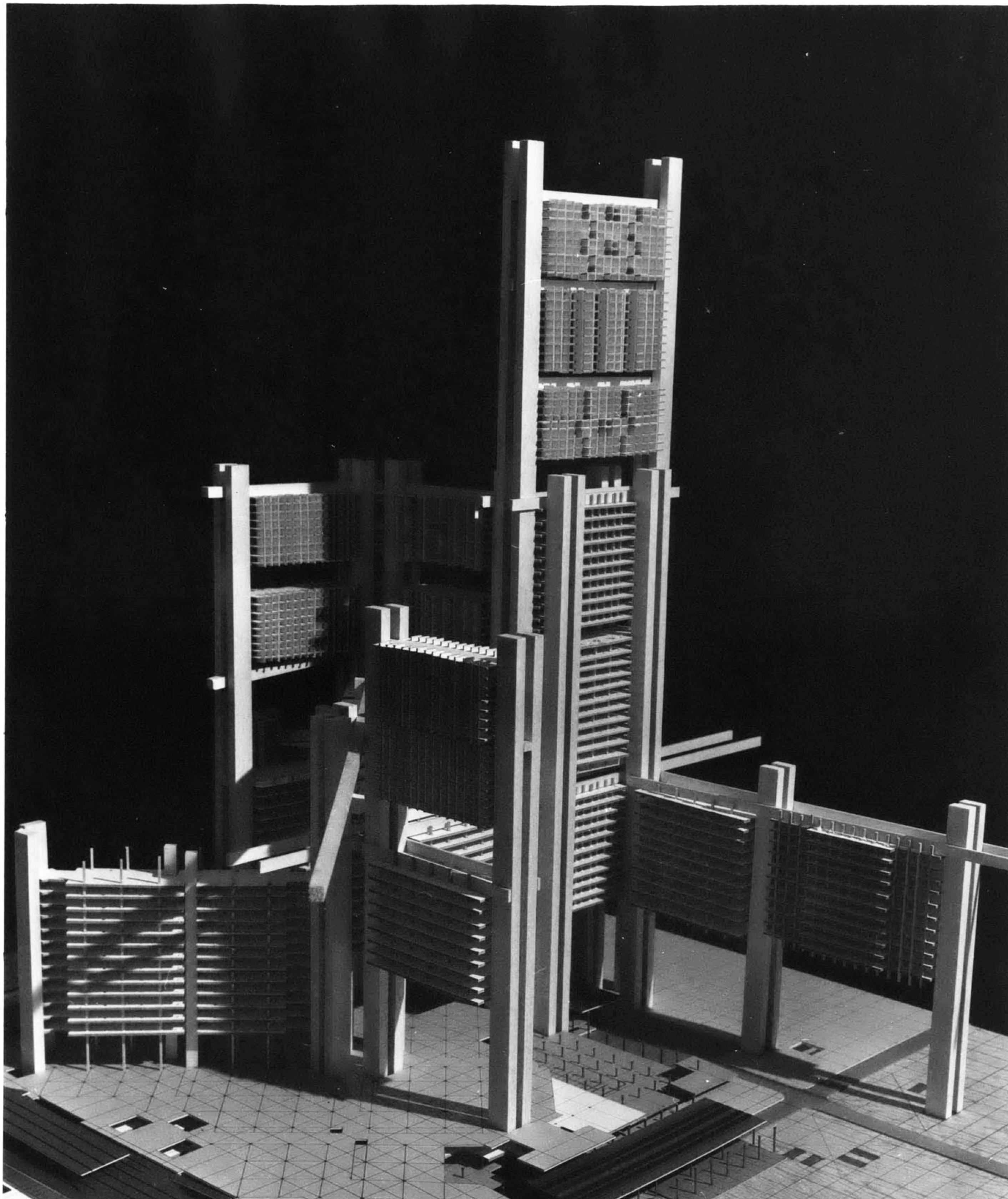
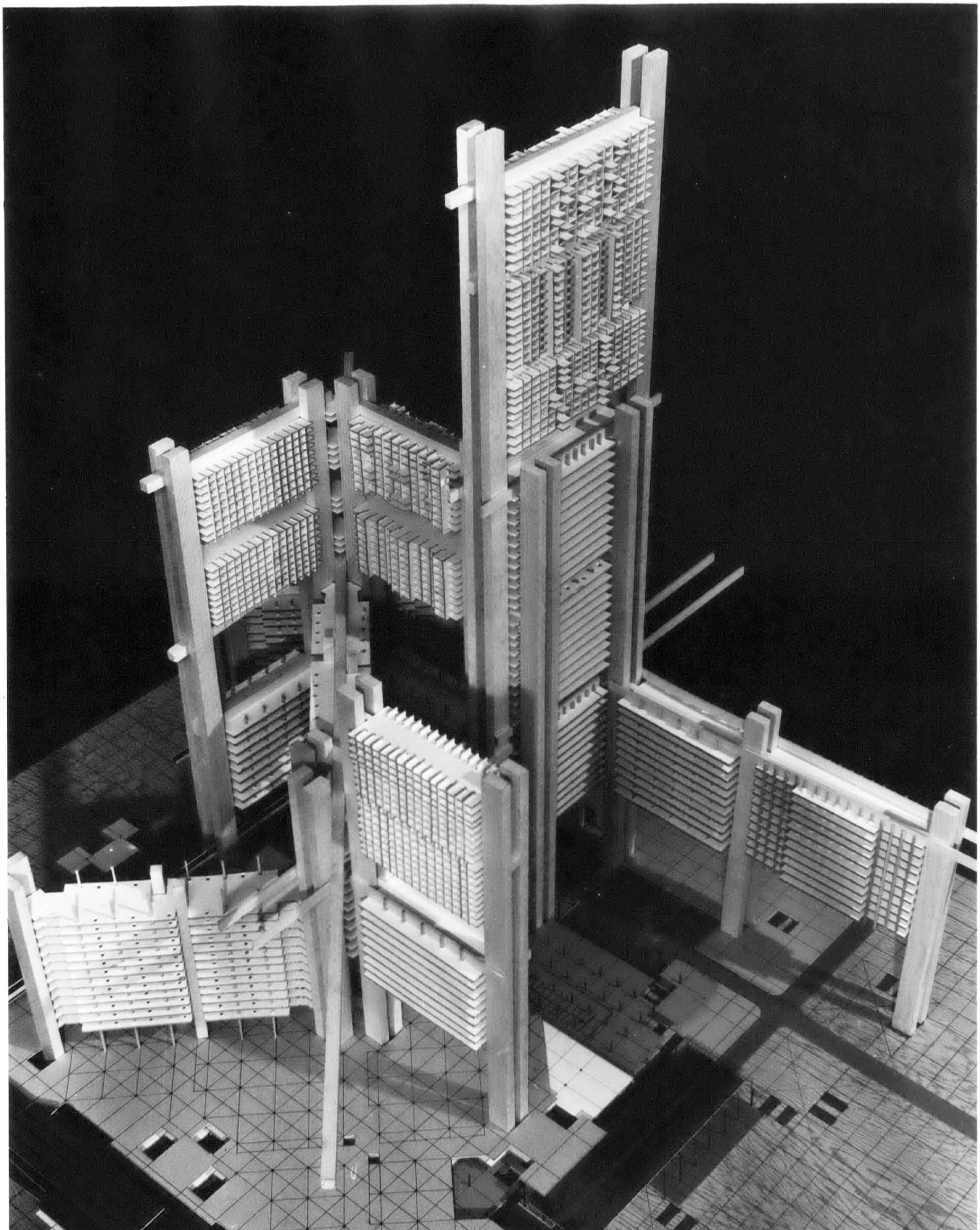
SPRING 1968

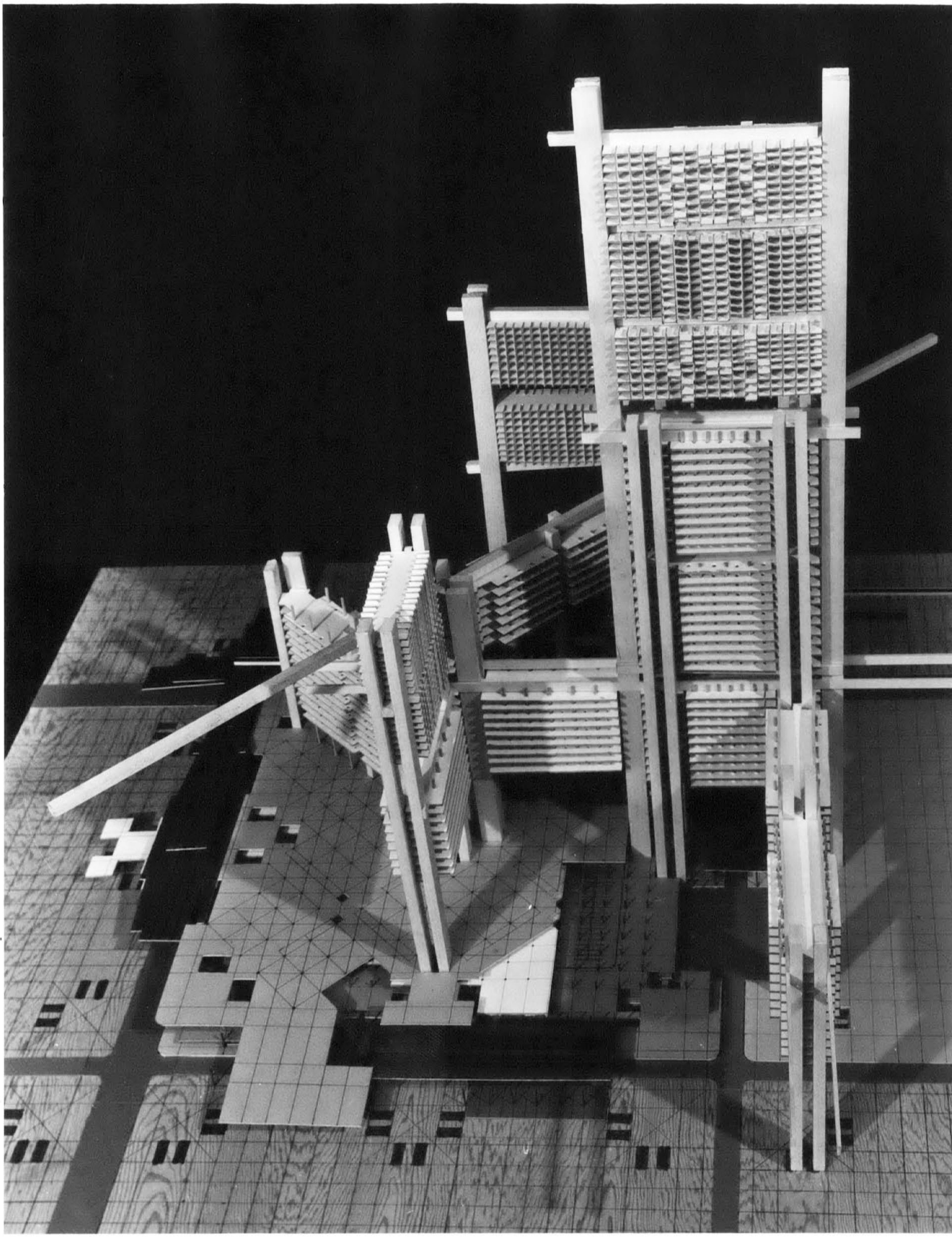
PHOTOGRAPH'S OF THE CITY SYSTEM MODEL











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AN INTEGRATED BUILDING SYSTEM

By: Keun Sup Lee

ABSTRACT

A LABORATORY BUILDING FOR RESEARCH AND DEVELOPMENT

Keun Sup Lee

Submitted to the Department of Architecture on June 17, 1968 in partial fulfillment of the requirement for the degree of Master of Architecture.

This portion of the thesis, completed during the first semester, is included upon the thesis advisors recommendation to provide a specific reference point to the main thesis of THE CITY AS A SYSTEM to show a detailed development of a building system. The major objective was to design a "prototype" building to be used for laboratory research and development. The building is conceived as a total system of circulation, services, and construction.

The system was given special emphasis to allow for expansion at any point, both internally and externally, as well as for maximum continuity of spaces, both horizontally and vertically. These spaces will be readily divisible by a modular partitioning system where required, and provided with a modular supply of services. The building's construction is based on the use of pre-stressed concrete elements post-tensioned to provide for a totally prefabricated component system with a standardization of its technical capabilities - a valid and honest expression of responsible architecture.

Thesis Advisor: Eduardo F. Catalano
Title: Professor of Architecture

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Waclaw P. Zalewski, D. Tech. Sci.
Professor of Structures

Charles Crawley
Mechanical Consultant, Cambridge, Massachusetts.

"The ever increasing size of contemporary buildings has brought the problem of structure to the forefront... .....Structure has assumed such formal importance as to become the central feature of architectural design. In structural architecture the forces of compression, tension, moment, and shear become a clearly legible pattern of stress and just as clearly legible a pattern of neutralization of stress--visable and comprehensible, demonstrative of the properties of the materials with which the forms are executed."

Gyorgy Kepes
<u>Structure and Art in Science</u>

INTRODUCTION

The purpose of this program was to study a prototype building at a scale level of construction over 1,000,000 square feet as an integrated system of space, structure, and services to be used for the development of scientific and technological research.

The functional requirements for this research facility dictated two primary spatial categories--the static and the dynamic. The static spaces include those which serve the basic needs of the building during its lifetime. These needs are: vertical pedestrian circulation (elevators and firstair cases); mechanical rooms; and plumbing supplies; all types of service pipes; washrooms and maintenance storage areas.

The dynamic space requirements are useful in two broad categories. The first being areas where scientists and administrative personnel work independently or in groups--office spaces. The second is areas for laboratories and workshops where complex arrangements of three dimensional instruments and research components are developed in preparation for final production by the support industries. This latter space requires large column spacing and a highly flexible system of services to meet both present and future demands of the use described above. The physical relationships between spaces are indeterminates; for they vary as widely as the type and magnitude of the projects developed.

The building system is an integrated synthesis of various support systems into a coordinated development of the following subsystems:

1. Structural system
2. Circulation system
3. Spatial usage system
4. Mechanical service system
5. Utility service system

6. Electrical service system

7. Lighting service system

In addition to having a flexible generation pattern for horizontal growth as needs develop over time; it is also necessary to provide for vertical change or flexibility as well. Therefore, the system should be able to adapt to three general height criteria:

1. low-rise development (5 to 8 stories);

2. medium-high rise construction (12 to 18 stories); and

3. a complete high rise tower complex (20 to 30 stories).

General Design Requirements:

The following are the general requirements considered in the research laboratory:

1. Design:

The design will develop from all the requirements involved together with restrictions imposed by the local bylaws according to the following factors:

a. type of building--single story or multi-story according to required concentration;

b. grouping of labor or grouping of work on each floor: one, two, or more per room;

c. small rooms or large;

d. proportion of laboratory to office space;

e. sharing of common facilities (technical rooms), stairs and escapes, rising mains, power links and fire sections.

Today one frequently finds off center corridors producing rooms of different depth on either side of the corridor, with the larger laboratories on the deeper side, and with writing rooms and special rooms on the other. A multi-story building with two corridors and an inner area without natural light has not proved popular in Germany, but a move in this direction is exemplified by the two laboratories of the B.A.S.F. at Ludwigshafen. Such a design has advantages as the inner area can be utilized for constant temperature rooms, cold rooms, physical rooms and balance rooms, etc.

2. Corridors:

Where the doors open into the corridor, the width should be 8'0" to 10'0".

3. Staircases:

The number of staircases and their size depends on the size of the building and the number of people working in it. In buildings of fireproof construction, the location of required fire stairs exists in multi-story buildings should be not more than 150'0" from any given room. There should also be provisions for a minimum of two means of egress.

4. Ceiling Height:

The interior height of the normal laboratory is between 10' and 12'. In large laboratories of rooms of great depth the height must be increased to 14' - 15'.

5. Floors and Ceilings:

The load bearing capacity of the floor should not be less than 150 Sq. Ft. or better 200 Sq. Ft. The floors of "hot laboratories" in laboratories handling radioactive isotopes should have load bearing capacity of 350 Sq. Ft. because of the heavy load of lead bricks or protecting screens which the benches and fume cupboards are required to carry.

6. Doors:

Doors to laboratories should have a width of not less than 3' - 6", preferably 4'0", so that equipment can pass through with ease. The entrances to lecture theatre, engineering workshop or production laboratory should be fitted with double doors. Similarly it is very convenient to use a double door of a total width of 4'6" to the laboratory, one of the doors having a width of 3'0" and providing the normal means of entrance and the other 1'6" which is only opened when moving equipment or furniture.

7. Working Areas:

In research laboratories the term working area refers to a unit which fulfills the needs of the physicist or chemist and his assistants; the variations depending on the type of work for which it is designed and the facilities provided, including washing facilities, balance tables, titration benches and provision for writing areas.

The design depends on a fundamental question of whether separate rooms are required for each work place or whether they can be arranged in the form of cubicles in a larger space. As a rule these cubicles are placed on both sides of a central corridor. When the cubicles are 25'0" to 40'0" deep it is possible to have the corridor off center with deep cubicles on one side and smaller cubicles for specialist equipment, balances and offices on the other. Cubicles which are open to the corridor can be screened from each other by using half glazed partitions or fume cupboards, and according to the type of work involved such cubicles can be equipped with island benches, wall benches, balance tables, desks, etc. Space must be provided not only for built-in furniture but also for movable and free standing items of equipment such as drying ovens, refrigerators, high vacuum installations, etc.

8. Space Requirements:

A minimum of 350 Sq. Ft. gross area (total floor area calculated from external dimensions) per person should be adopted, but in order to allow for increase of staff and operational flexibility a figure of 400 Sq. Ft. gross area per person is advisable for new laboratories with an estimated use factor of 70 percent. The use factor is the ratio of useful area (area calculated from inside room measurements) to gross area.

9. <u>Services:</u>

Every laboratory must be equipped with the necessary services such as ventilation, water, gas, compressed air, steam, sinks with outlet and electricity. Electric conduits parallel to water pipes must lie above the latter so that short-circuits cannot occur in the event of damage to the water pipes. The benches should have evenly distributed horizontal and vertical lighting with an intensity of 250 to 500 lux. The laboratory should have both a.c. and d.c. electricity supply.

General Proposal:

A one-way structural system was eventually chosen over a two-way system for the design of a research laboratory for the following reasons:

1. Ease of erection in placing linear elements which are self supporting.
2. Reduction in the number of construction joints-less error in total tolerance variation.
3. Elimination of time-consuming scaffolding.
4. Larger cost reductions per unit piece in larger elements.
5. Reduction in transportation costs.
6. Flexibility in placing vertical service cores or openings.
7. The savings provided in the structural economy of two-way cantilevers.
8. Larger reductions in total erection time--hugh labor savings.
9. Superior integration capabilities of the linear structural system for mechanical services. This provides for a reduction in total floor to floor height--an appreciable savings in cost. This is feasible with longer span elements, where flush girder framing is no longer a prerequisite for flexible partitioning.
10. General compatibility with the precast concrete industry within the United States which can produce only linear elements on a competitive basis.

It is for these reasons that an appropriate solution within the limits of an one-way structural system was sought.

Not only does the one-way system provide appreciable cost to the structure which persists over a long period of time--initial capital investment cost, but it also provides many reciprocal savings as well in the following areas:

1. Reduction in material and labor costs for installing the mechanical system.
2. Greater flexibility in lighting layout.
3. Ease of installing and repairing all of the various services required for a complex laboratory spaces which change constantly.

Design Solution:

1. Selection of Material

Precast reinforced concrete was selected as the structural material because of its fireproof capacity and its finished structural expression upon delivering to the site. The advantage of being able to continue construction during cold weather with this system now offsets any seasonal advantage that steel maintained. The precast members may be cost under controlled conditions within a plant during inclement weather and assembled on the job site at full structural strength. In scientific research laboratories, where safety is a premium criteria in the event of an explosion or fire, the use of a durable fireproof material such as concrete is a decided advantage and economy; both in maintenance and in insurance premiums.

Secondly, the material provides a dead load weight which will resist minor vibrations and transfer of floor movements which may affect measuring devices. Thirdly, many science research laboratories maintain a variety of testing instruments which produce a relatively heavy live load--this can be offset by prestressing the linear floor elements with sufficient comber to offset this possibility.

2. General Planning Criteria

Compared to the progress made in other fields of technology and science, architecture has developed at a rather slow pace in the past two centuries. The enormous problems facing an architect today force him to use all the potentialities of today's modern technology. In many countries today there is a critical shortage of construction workers, and at the same time, a large demand for constructed floor area due to the growing population and the constantly rising standards of living.

The dynamics of construction during our time has urgently required a re-evaluation of our traditional way of construction. Not only is there a demand for more building space, but also a dependency on flexibility since occupancy or functional requirements soon render a volume obsolete. In order to synthesize both this immediate request for larger spatial areas coupled with the advancement of reinforced concrete technology, we propose the concept of a LINEAR MEGA-STRUCTURE.

This concept provides for maximum internal and external transformation within a structural frame of preference.

The traditional method of column and slab construction had its own limitation such as planning flexibility, circulation flexibility, and adaptibility for future demand and change requirements. The usual limitation of spanning systems was approximately 50'-60'-0"; and if it spanned more than 60', the depth of the slab became unreasonably increased to the ratio of ceiling height and structural slab.

The ratios varied as much as 1:3 (4'0" depth of integrated system of mechanical and structural/ceiling height of 12'0") for a 60'0" span, to as much as 1 : 2 for a 90'0" span (floor depth of 6'0"/ ceiling height of 12'0"). This meant that approximately 1/4 or 25% of the usual volumetric floor area was dedicated to both structural mechanical spaces. Not only is this an obvious misusage of material and effort, but it proved to be an inflexible system in terms of vertical spatial flexibility. With the inclusion of permanent service cores for vertical movement of services and people, the location of circulation areas (hallways) imposed further limitations.

Therefore, the LONG SPAN-MEGA-STRUCTURE, recognizing this weakness, takes this idea of increasing depth of the structural and mechanical floor system into a new dimension with the following concept:

a. Why not increase the structural depth to 10'0" with a larger span of 120'0" and then support or suspend three floors?

b. Why not utilize the resultant mechanical and structural space into usable floor area by resegregating the mechanical lines of distribution?

3. Structure

From these two challenging questions, the final design of the mega-structure developed as follows:

a. A staggered system of large 10'0" deep mega-trusses (98' and 91' long respectively for column girder and central span girder) which are located on 60'0" centers--every other floor. The major girders are used in pairs spaced 22'0" apart--center to center. The open clear span longitudinally is 126'0"; and 142'0" transversely.

b. Each of the major mega-girders fall upon a composite column (22'0" x 24'0") which provides for a variety of service spaces--from firecase stairs, elevators, to washrooms, and storage areas. The composite columns, two to a support node, allow for a 10'0" wide circulation hallway.

c. The upper floors above the major mega-girder are supported by secondary columns located 42'0" from center to center, two to a bay. On top of these columns rest secondary girders 3'0" deep. These span between the points of zero moment--allowing for pure shear connections. Perpendicular to this major and minor system of girders run the precast double-T beams which span 42'0" from center to center. The connections are also located at inflection points of zero moment-- where only the problem of shear has to be accounted for. In addition to this concept of double cantilever, is the usage of the spanning elements to be supported directly above or below the main 10'0" mega-girder.

This provides for the segregation of mechanical services that we are looking for. Therefore, the main mega-girders are not flush-framed, but simply supported upon or simply bolted on from beneath. This provides for two floor to floor depths: The smallest located at mega-girder level is a floor to floor depth of 12'6" and a clear ceiling height of 10'0" . The largest located between mega-girders provides for a floor to floor depth of 15'0" and gives a clear ceiling height of 12'0". Because this system remains a clear expression of structure, the mechanical system is easily coordinated from its mechanical channel into the depth of linear precast double-T beams. This simplicity of coordination provides for maximum economy, especially for changes over a long period of time, where new lines have to be added, deleted, or altered.

d. Please note that the mega-girders are punctured at their respective centers according to the principle of maximum moment, but minimum shear. Therefore, the openings large enough for a person to walk through are provided for. This enables the resultant floor zone to be readily usable for flexible occupancy.

e. Because the mega-girder staggered truss system provides for hanging or supporting two other floors, a ceiling height variation of up to 38'0" is provided for. This clearly provides for larger experimental mark-up rooms, vertical testing equipment, auditorium, theatre and large storage rooms.

f. Finally, this system of double cantilevers for both major and minor systems provides for the maximum size of a precast concrete element to still fall safely within the limits of inter-state transportation. The following information are the relative comparisons:

MEGA-GIRDER DIMENSIONS:

Size	Max. Limit
1. Length = 98'	150
2. Width = 2'0"	---
3. Height = 10'0"	12' permit
4. Weight = 20 tons	35 tons

This represents a tremendous savings in economy of structure. The floor depth ratio is 1:5--a reasonable ratio; versus 1:2 in other systems.

4. Construction Sequence

The construction procedure provides for the following sequence of construction elements:

Step 1: Precast components are prepared at a precasting plant under quality control conditions by specifications supplied to him by the designer.

Step 2: Precast components, from girders, to columns and spanning double-T beams are transported to the site.

Step 3: The footings have been poured in place with steel leveling blocks to allow for grouting after precast columns are lowered into place.

Step 4: Place composite series of precast columns by a crane to a desired position.

Step 5: Over each column development place a 98'0" mega-girder--it cantilevers outward in two directions for a distance of 10'0" each.

Step 6: Place secondary system of columns, girders, and infill system upon each other. This has to be completed for each structural bay until the vertical limits are achieved.

Step 7: This same procedure is initiated linearly, or transversely in adjacent rows or columns. Now this portion must reach a vertical height equivalent to the previous, step number 6.

Step 8: Take the infill system of precast linear double-T's 42' long and place them as soon as prior construction sequence permits. They are supported by protruding end and base alignment plates that are welded making a homogeneous connection.

Step 9: The floor topping is poured to complete the sequence.

Step 10: The next bay or floor is ready to go through the same sequence.

5. Mechanical System

The basic structural system is designed to integrate the mechanical components so that the two systems can perform harmoniously. The mode of circulation is through the cores which house the air system, toilets, telephone closets, elevators, and storage spaces. The cores fall into two specific categories:

1) Structural dependent cores which provide for firestairs and the mechanical duct spaces at every other bay of the staggered Mega-girder system.

2) Structurally independent service cores which are spaced between structurally dependent cores whenever functional, code, and additional mechanical needs require such additional facilities.

Air System:

A low velocity single duct system, with supply and return air ducts provided. The air is supplied and returned vertically through the cores. The supplied air is at 2,500-3,500 FPM. Every other floor level contains the main horizontal duct which passes through a sound attenuator into horizontal plenums at 1,200-1,600 FPM, and distributes perpendicular to the diffuser at 600 FPM. The air is controlled by electric means and either comes in cool or is heated by electric coils at the diffuser, thus giving an individual control at each module. The thermostatic control adjusts the pressure sensitive membrane in the coil box. The structure is designed to house within the double "T: rib of 2'6" - supply air and return air provided together at intervals of either 7'0" or 14'0" from center to center. The mechanical system is integrated with the fluorescent lighting system to provide economical absorbtion of high heat loads given off by the electric tubes. The air system is provided with ample room to be converted to a high velocity duct system as deemed necessary by future growth requirements.

Lighting System:

The 2'6" x 10'0" module within the structural channel of the double - "T" unit will accomodate the standard lighting fixture of 60 F.C. They will be placed in each module to give a uniform lighting level. These lighting channels occur at 7'0" center to center for even light distribution.

Acoustics:

The control of acoustics (sound isolation, reverberation, etc.) is solved throughout the structure by providing a 4'6" channel between the lighting and mechanical channel for the placement of an acoustic absorbtion panel which in turn covers the service pipes. The placement of plaster diaphragms may occur at 10'0" intervals to prevent leak occurances through any transverse partitioning systems.

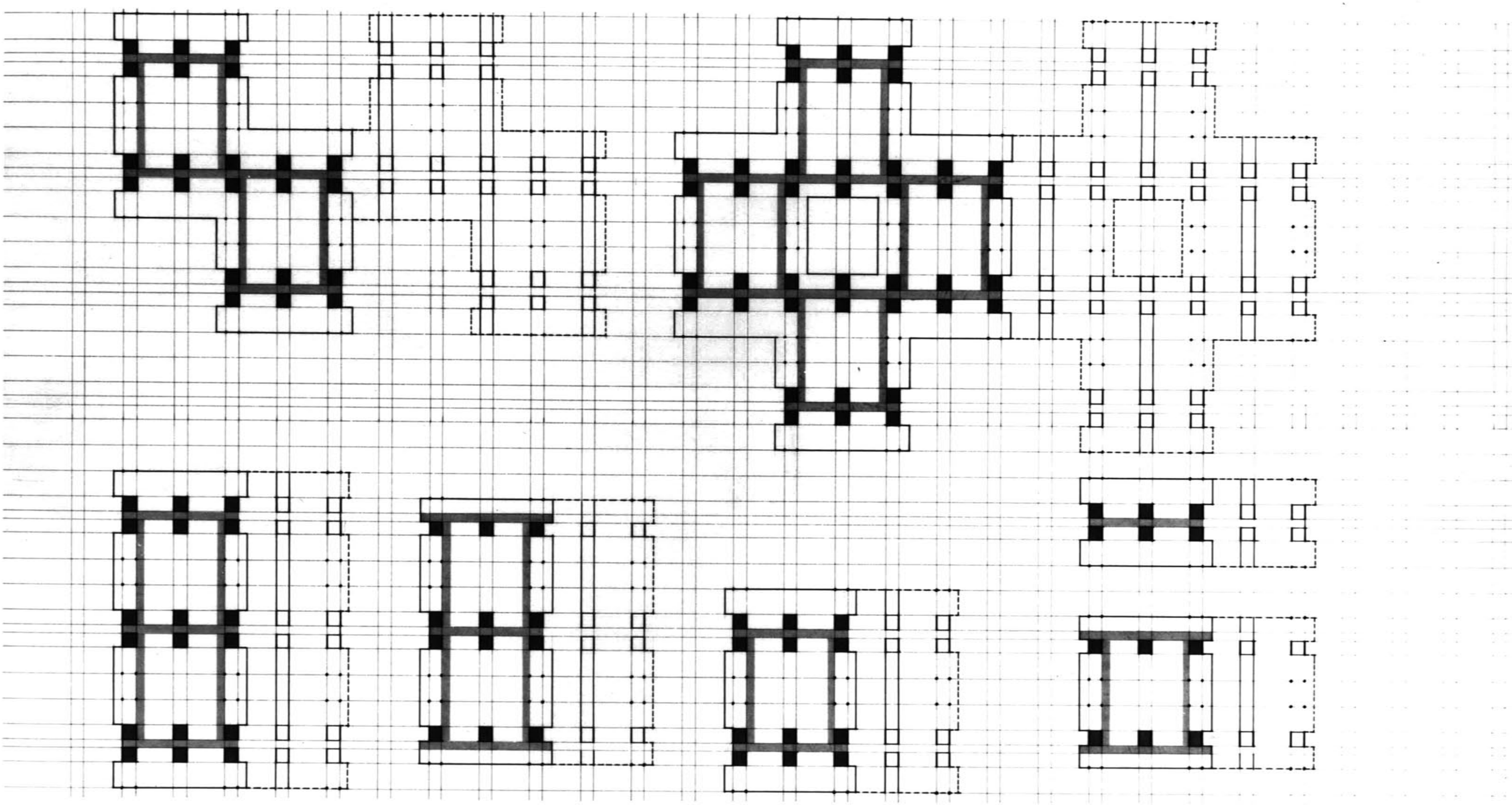
Planning:

The planning unit is based on a rectangular module of 5'0" x 10'0" with a 2'0" coordination space infilling between modules.

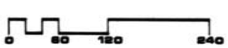
Plumbing:

These include vertical wet lines (hot, cold water, waste, roof drains, gas, vents) that run through the "T"s and to the cores or through the columns, which are more accessable.

DRAWINGS OF THE BUILDING SYSTEM



PLAN VARIATION & GROWTH PATTERN



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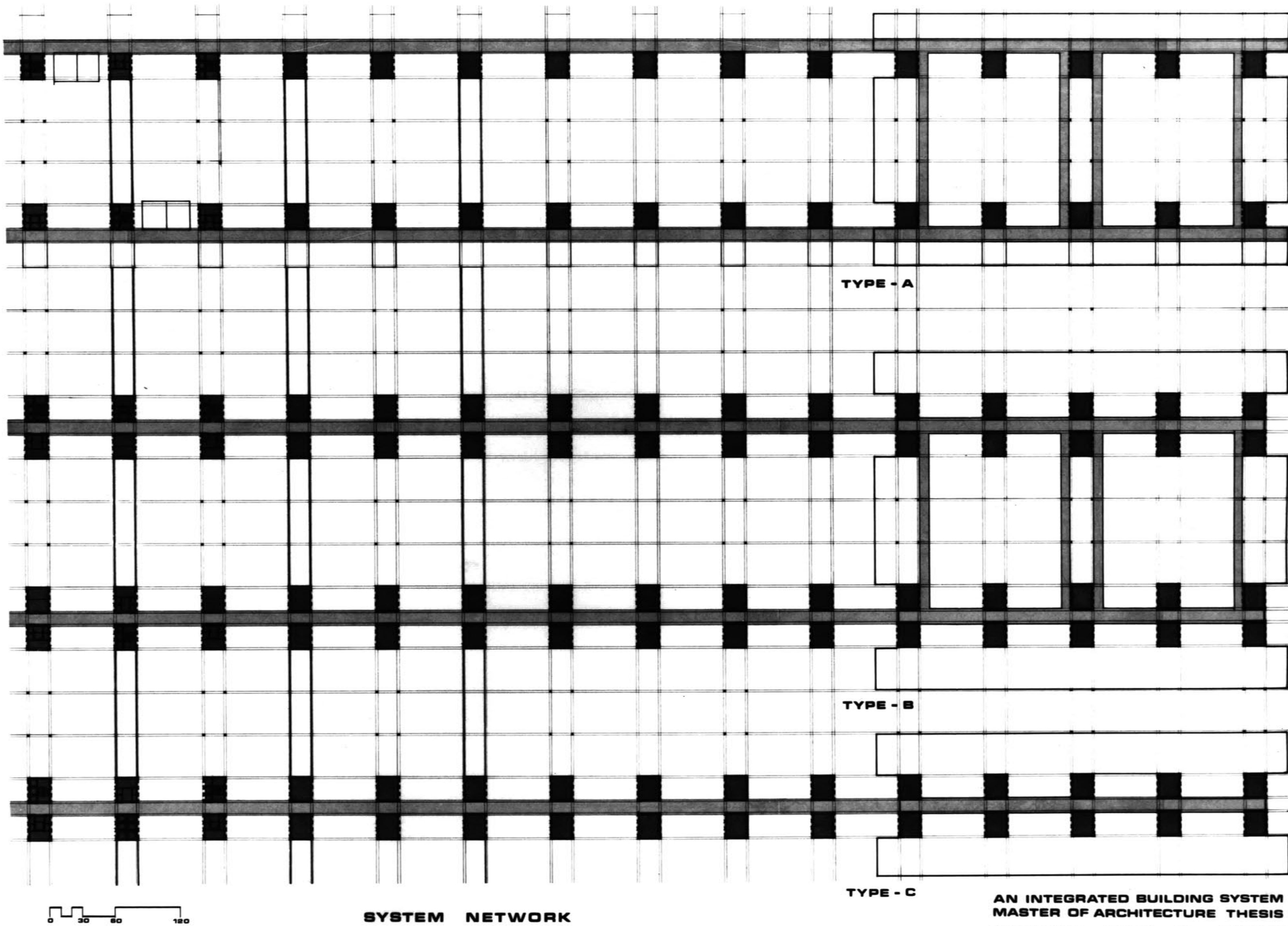

SYSTEM NETWORK

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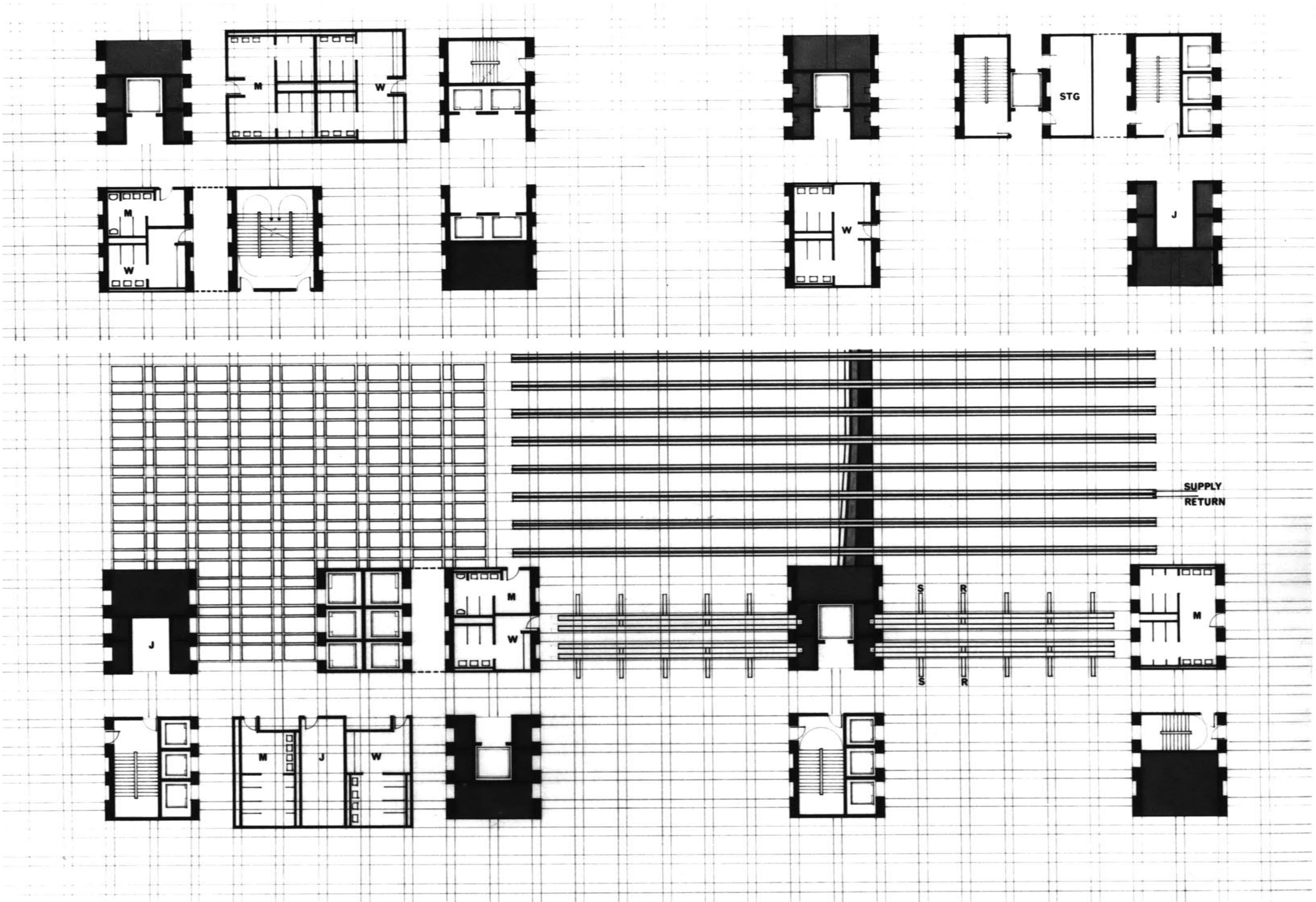

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CORE ARRANGEMENT VARIATION

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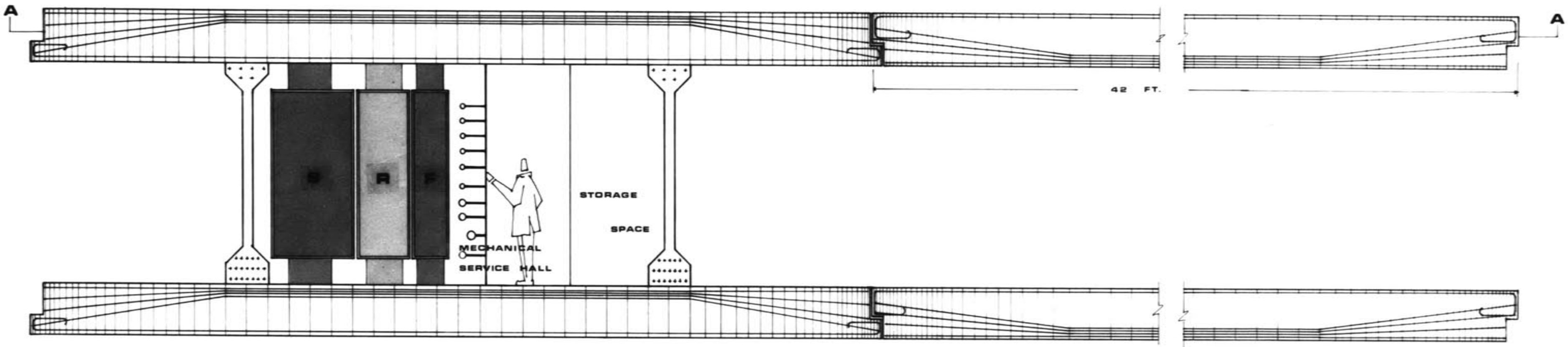
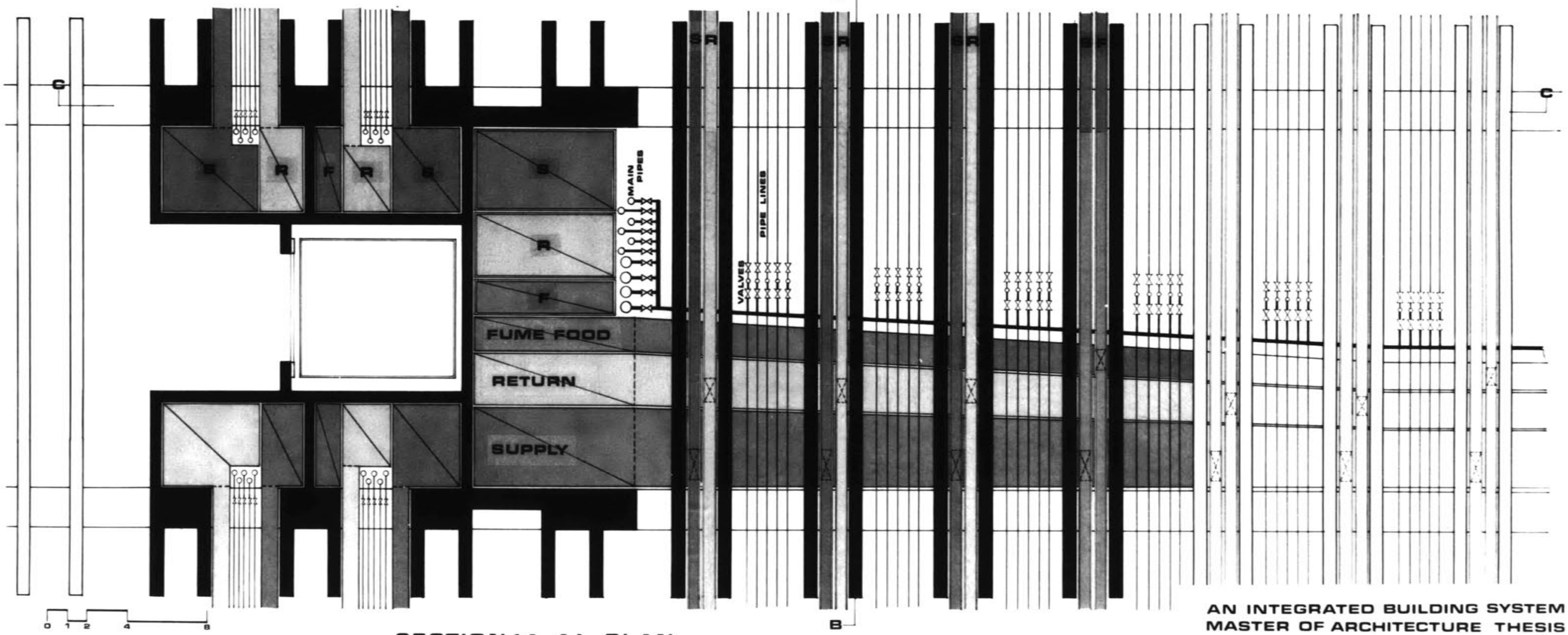


SECTION (B-B)



SECTION (A-A) PLAN

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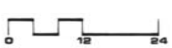

SECTION - TRANSVERSE

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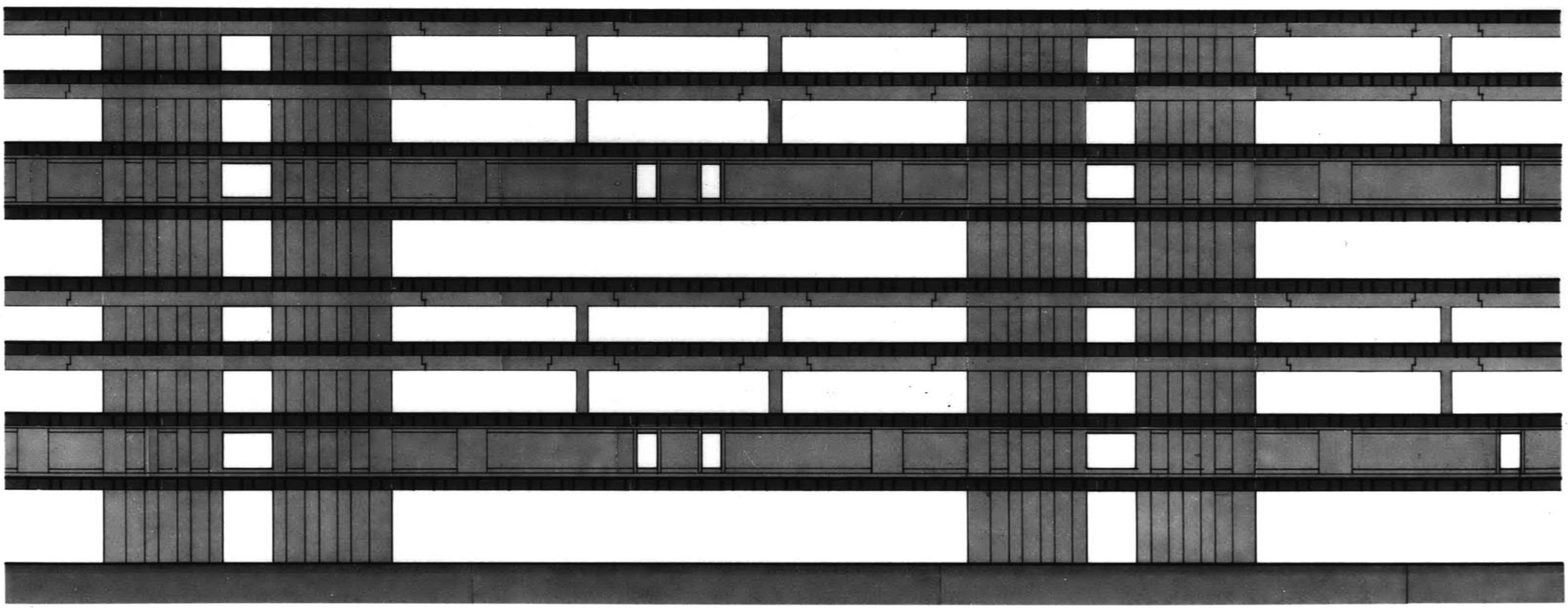

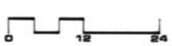

SECTION - LONGITUDINAL

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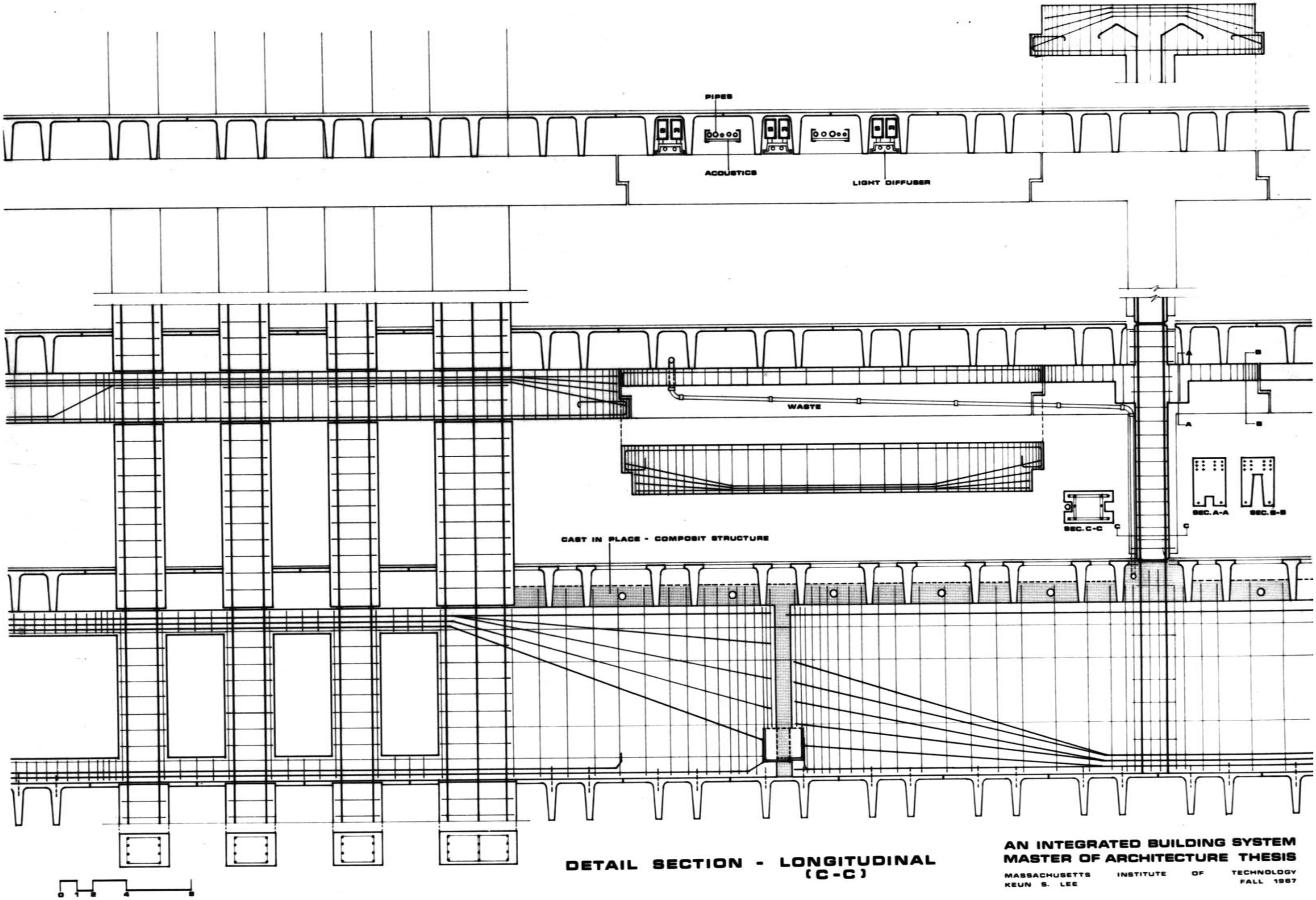

DETAIL SECTION - LONGITUDINAL (C-C)

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PHOTOGRAPH'S OF THE MODEL